THE JOURNAL

OF THE

ROYAL AERONAUTICAL SOCIETY

(FOUNDED 1897 in succession to the ANNUAL REPORTS)

Edited for the Council by J. LAURENCE PRITCHARD, Fellow

No. 168 DECEMBER, 1924 VOL. XXVIII

NOTICES

Election of Members

The following members were elected at a meeting of Council held on November 11th:—

Associate Fellow.—Mr. J. S. L. Oswald.

Students.—Mr. F. G. Evans and Mr. R. S. Stafford.

R.38 Memorial Prize

The Council have decided that no paper submitted in 1924 for the R.38 Memorial Prize is of sufficient merit to justify an award. In the circumstances they have decided to award the prize for 1924 to Mr. C. P. Burgess, Commander J. C. Hunsaker and Mr. S. Truscott for their paper on "The Strength of Rigid Airships," which was submitted in 1923 and received special mention in that year.

R.38 Memorial Prize, 1925

From the income of the R.38 Memorial Fund a sum of twenty-five guineas will be offered as a prize for the best paper received by the Royal Aeronautical Society, on some subject of a technical nature in the science of aeronautics. Other things being equal, preference will be given to papers which relate to Airships.

The prize is open to international competition. The Royal Aeronautical Society retains the right to withhold the prize if it is considered that no paper is of sufficient merit to justify an award.

Intending competitors should send their names to the Secretary of the Royal Aeronautical Society, 7, Albemarle Street, London, W.1, on or before December 31st, 1924, with such information in regard to the projected scope of their papers as will enable arrangements to be made for their examination. The closing date for the receipt of papers will be March 31st, 1925.

Papers, which must be submitted in either French or English, should in all cases be typed, and a copy should be retained by the author, as the Society can take no responsibility for the loss of copies submitted to it.

Successful papers will become the absolute property of the Society, and will in most instances be published in the JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY. A signed undertaking must accompany each paper to the effect that publication has not already taken place and that the author will not communicate it elsewhere until the Society's award is published.

The Society attaches special importance to papers showing original work, and due acknowledgment must be made by the author of the source of any special information.

Lectures

It is regretted that owing to illness Colonel Searle's lecture, on "The Maintenance of Commercial Aircraft," will not take place on December 4th. It is hoped to arrange for it to be read later.

The following lecture will complete the first half of the present Session:—Dr. R. A. Watson Watt, "Recent Studies on Radiotelegraphic Atmospherics," on Thursday, December 18th, in the Society's Library at 5.30 p.m.

The following will form the second half of the lecture programme:—

Thursday, January 22nd, 7.0 p.m.—Joint meeting with the Institution of Automobile Engineers, at the Royal Society of Arts, Lieutenant-Colonel L. F. R. Fell, "Light Aeroplane Development."

Thursday, February 5th, 5.30 p.m.—In the Library, Air Commodore C. R. Samson, "The Operation of Flying Boats in the Mediterranean."

Thursday, February 19th, 5.30 p.m.—In the Library, Major R. V. Southwell, "Some Recent Work of the Aerodynamics Department, N.P.L."

Thursday, March 5th, 5.30 p.m.—In the Library, Colonel Heald, "Some Medical Aspects of Air Transport."

Thursday, March 19th, 5.30 p.m.—In the Library, Captain Tymms, "Practical Navigation of Aircraft."

Thursday, March 26th, 5.30 p.m.—At the Royal Society of Arts, Dr. Eckener, "Modern Zeppelin Airships."

Library

The following books have recently been received and placed in the Library:—"Steel Construction of Aeroplanes," H. Harper; "All the World's Aircraft, 1924," edited by C. G. Grey; "The Report of the Empire Motor Fuels Committee," Vol. XVIII., Part I., Institution of Automobile Engineers; "Optical Measuring Instruments," L. C. Martin; "The Measurement of Fluid Velocity and Pressure," J. R. Pannell; "R.34," E. M. Maitland; "Aircraft of the World," F. A. de V. Robertson; and "A Study of War," Admiral Sir Reginald Custance.

Forthcoming Arrangements

Monday, December 1st, 8.0 p.m.—*Scottish Branch.*—Mr. F. T. Courtney, "The Difficulties of Aeroplane Experimental Development."

Tuesday, December 9th, 5.30 p.m.—Council Meeting.

Thursday, December 18th, 5.30 p.m.—In the Library, Dr. R. A. Watson Watt, "Recent Studies on Radiotelegraphic Atmospherics."

W. Lockwood Marsh, *Secretary.*

PROCEEDINGS

SECOND MEETING, 60TH SESSION.

A meeting of the Society was held at the Royal Society of Arts, John Street, Adelphi, London, on Thursday, October 16th, 1924, Lieutenant-Colonel A. Ogilvie, Vice-Chairman of the Society, presiding.

Colonel OGILVIE, who took the chair in place of Colonel Tizard, who was away through illness, in introducing Dr. Rohrbach, said that his name was no doubt familiar to everyone present, chiefly as the designer of the large all-metal Staaken monoplane. Dr. Rohrbach had been engaged with the Zeppelin Company on aeroplane construction, and had been solidly at work on metal aeroplane construction for about ten years. He had delayed his departure for England in order to be able to give the Society the results of his latest tests on his seaplane, and show slides of flying trials carried out within the last few weeks.

LARGE ALL-METAL SEAPLANES

BY DR. ROHRBACH.

I thank you very much for the honour of your request to read this lecture before you.

In preparing this lecture I anticipated your permission to give you only some personal experience and my personal opinion regarding large all-metal seaplanes, for I know rather little about the machines of other constructors.

There is no branch of engineering where a big machine does not give a distinct advantage over an equally powerful combination of several small units. In our special case of the seaplane, these general advantages of the big unit are so obvious that they were recognised very early, and therefore I must not take your time by repeating them. I only mention the most outstanding quality of the large seaplane, *i.e.*, its increased seaworthiness.

As far as the general advantages of the all-metal construction of seaplanes are concerned, I think again I must not take your time by talking of them. It has been known for a long time that an adequately built metal machine is far less affected by sea-water or climatic conditions than a wooden one. It is proved by experience that an all-metal aeroplane structure can be built, on the lines which I am going to describe, 15 or 20 per cent. lighter than one of wood for the same purpose. In service the weight of a wooden seaplane is often still considerably increased by the water penetrating into the wood.

But the difficulties which stand between the idea and a satisfactory type of the large all-metal seaplane are as big as its advantages. The large wing structure has a most unpleasant tendency to come out very heavy—in most cases heavier than calculated, and the great bottom of the floats or boat wants great strength in order to resist everywhere the local stress caused by hitting waves during starting or alighting.

However, if one tries to incorporate in the same machine the solution of both problems, that of the large seaplane and that of the all-metal construction, the task becomes relatively easy—first of all from the financial point of view. The large seaplane is, and always will be, that type of flying machine which costs most per b.h.p. or per kilogram. The expense which is needed for the development of a satisfactory type of wing structure, boat bulkhead, or any of the

details of a seaplane, is more or less independent of its size. Therefore, these research expenses are relatively small compared to the high price of a large seaplane and would be prohibitive in the case of a small aeroplane. It is on account of these financial considerations that I started the work in my own firm with the construction of as large a seaplane as could be built without too great a risk.

As in the big Staaken monoplane, the whole structure was built of duralumin.

There are two constructional advantages of the machine exclusively built out of duralumin or a corresponding kind of light alloy over those in which a combination of steel and light metals is used. The main advantage of the all-light-metal construction is the absence of corrosion. Most high-class steels contain a certain percentage of nickel and chrome. Both these components cause such an electrical tension between steel and duralumin that the latter is destroyed in the presence of sea-water. Therefore, the less connecting points between steel and duralumin the better. The few unavoidable steel-duralumin connection points, as for instance fittings for steel struts, wing connecting bolts, etc., can be well protected against the access of sea-water by red lead, or another protective painting.

The connection of duralumin with steel members involves more weight than one of duralumin with duralumin, for the dimensions of connecting bolts and rivets must be adequate to the stress limit of the weaker material—that is, duralumin—so that relatively too great holes are bored through the steel members, necessitating a certain percentage of extra area in order to avoid local weak points in the steel parts.

The pure steel construction avoids corrosion, it is true, but it rusts on the sea, as soon as the protective coatings are hurt in the flying service; and the material even of the main parts is too thin. A steel skin of wings and boat is impossible.

The all-duralumin construction with its stressed skin is the only way to secure to the aeroplane structure all the valuable qualities of steel ships. The material of all parts, including the rivets, is the same. The material is used in its most simple form, *i.e.*, as plain plates and profiles formerly drawn and now rolled out of strips.

In order to avoid local weakness of the plates of a duralumin structure, for instance, a wing with stressed skin, one must find out such an arrangement of the principal members of the structure that the plates are as thick as possible where the greatest stress is to be transmitted. In some cases the stress limit of the skin can be materially increased by stiffening profiles connected with the plates by a sufficient number of rivets, *i.e.*, the space between the rivets must be such that a buckling of the plate between two rivets is avoided.

If the stressed skin, however, is to be used for the wings of large aeroplanes, one must reduce the dimensions of these wings as much as possible by employing a high wing loading. For the small dimensions of the heavily loaded wing reduce on the one hand the bending and torque moments, and improve on the other hand the thickness/length ratio, *i.e.*, the stress limit of the compressed members, because the square area of these members is not so much reduced as their length when the wing loading is increased. Consequently, one gets with the high wing loading rather thick plates with high stress limit per square inch. These thick plates give for the user of the machine a structure which cannot easily be damaged by the hand or feet of the mechanic.

A further advantage of the small heavily loaded aeroplane is its relatively smaller price, because the labour is almost the same whether one builds one square foot of a light or heavy wing, but a smaller amount of material is necessary to build the relatively light structure of a heavily loaded aeroplane. Last but

not least, thicker plates are cheaper than thin ones, and it is easier for the workman to build something out of thick plates than out of thin ones.

In my opinion, the high wing loading has still greater advantages than that of making the stressed skin construction a practical proposition from the weight point of view. The smaller dimensions allow smaller sheds, less influence of wind on the wings, *i.e.*, easier manœuvring on the water, higher speed in the air, better manœuvrability in the air and safer landings.

I think these various qualities of the seaplane with high wing loading should be discussed a little more in detail.

The curves in Fig. 1, which are calculated for geometrically similar machines of the same factor of safety for flight, landing, etc., show the percentage weights of the principal items of seaplanes of different total weights. If the total weight of an aeroplane is increased without increasing the wing loading, the weight percentage of the flying structure grows rapidly with the same factor of safety.

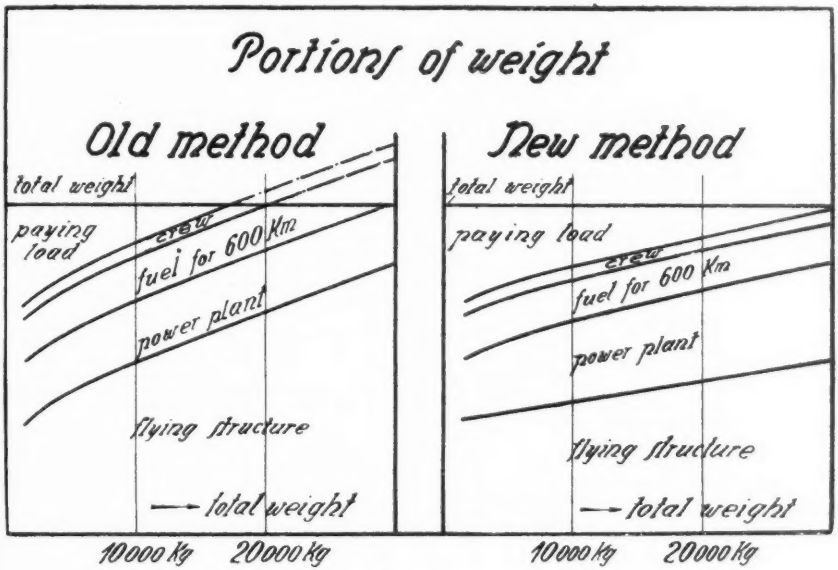

FIG. 1.

The weight percentage of the power plant remains the same if the relative margin of power is the same for the small aeroplane as well as for the large one. I understand by the relative margin of power the ratio between the power which is required to fly and the power available at the propeller hub if the angle of incidence corresponding to maximum climb is maintained.

The weight percentage of the fuel necessary to cover a certain distance is the same for small and large planes, since their speed is roughly the same.

I might mention here that in fact the speed of the big machine would be a little higher, because its dead resistance does not grow in the same proportion as its wing area. The result is that the weight percentage of the paying load is much smaller with big machines than with small ones. The only way to escape this fatal connection between the pay-load percentage and the size of machine was to build the large machines with relatively high power loading, and therefore bad manœuvrability and corresponding small factor of safety.

If, however, the wing loading is increased with growing total weight of the machine, the weight percentage of the flying structure, with the same factor of safety, grows very slowly. The reasons for this have already been mentioned in speaking of the advantages of the combination of stressed skin and high wing loading. The weight percentage of the power plant is not independent of the size of machine in this case, but is increased to 1.167 power of the total weight of the machine, if the law of similarity which is given in Table I. is adopted for comparing small and large aeroplanes and if these machines have the same relative margin of power.

TABLE I.

PRINCIPLES OF BOTH WAYS OF ENLARGEMENT.

	Old method (Lanchester).	New method (Rohrbach).
Proportion of lengths	$a^{0.5}$	$a^{0.333}$
,, ,, wing areas, etc. ...	a	$a^{0.666}$
,, ,, total weights ...	a	a
,, ,, speeds	1	$a^{0.167}$
,, ,, engine power ...	a	$a^{0.167}$
,, ,, wing loading ...	1	$a^{0.333}$
,, ,, power loading ...	1	$a^{0.167}$
,, ,, radii of curves ...	1	$a^{0.333}$

The relatively high power plant weight is necessary because for the same angle of incidence the lift/drift ratio of small and big machines is of the same order of magnitude, so that the speed of the more heavily loaded machine is higher and therefore also the power which is transmitted to the machine during a certain time.

The weight percentage of fuel which is necessary to cover a certain distance is again the same for small as well as large machines, because the influence of the higher consumption per hour of the stronger power plant is counterbalanced by the shorter time required to cover the distance, which is a consequence of the higher speed.

The weight percentage of useful load is again smaller with big machines than with the small ones, but up to a certain size this relative increase of paying load is counterbalanced by other advantages, as higher speed, greater number of passengers per pilot, greater comfort, etc.

Fig. 2 gives the paying load for both methods increasing the size of aeroplanes, the old method with equally small wing loading for light and heavy machines and the new method with a corresponding increase of total weight and wing loading according to Table I. One can see from this that large aeroplanes with high wing loading carry nearly double the paying load than the conventional obsolete machine with small wing loading, if the total weight of both types is about fifteen tons.

Another curve of Fig. 2 shows that the time in which the machine covers a certain distance is much shorter with high wing loading than for a large machine with small wing loading. This difference of travelling time would be still more accentuated by the influence of the wind. If one calculates the cost for the transportation of one passenger over a certain distance on the basis of the present air traffic experience, the fare is much smaller for the passenger in the machine with the high wing loading.

Fig. 3 shows the proportion in which flying and landing speed are increased when the wing loading is increased with the size of machine. The time and the distance required for the start are longer for large machines than for small

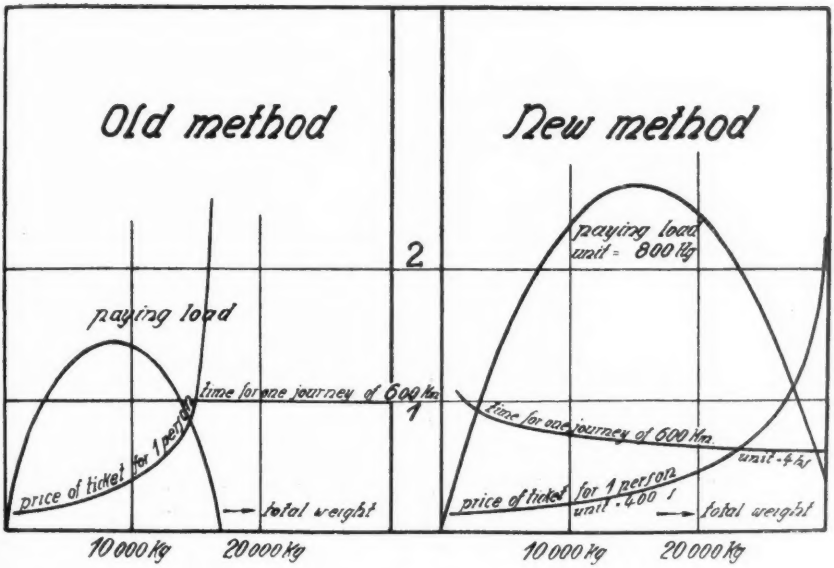

FIG. 2.

ones. In the case of the big machine with small wing loading, flying and landing speed, starting time and distance are independent of the size of the machine, if our original assumption of the same margin of power is maintained. The longer starting time and distance is no disadvantage for seaplanes because there is

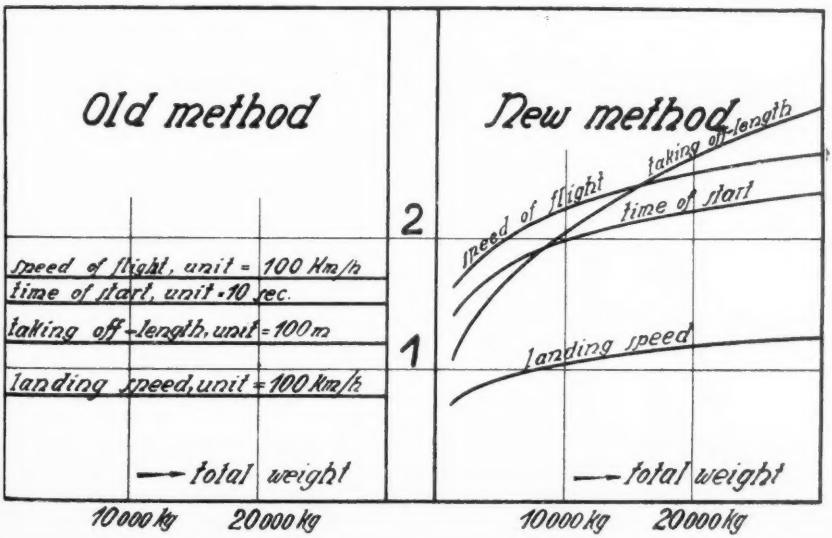

FIG. 3.

enough room. Apart from this, the starting time can be minimised by carefully tried-out shapes of hull and floats, and by a sufficient power reserve or supercharging device on the engines. The take-off time of the type of flying boat that is now being produced in Copenhagen is only 22secs. with full load in calm air. The higher the landing speed, the greater the independency of gusts and of the direction of the wind.

Of course, the bottom of the boat and floats have to withstand greater shocks during start and landing with greater velocity. These shocks increase as the square of the landing speed, but since also the lift per square foot is increased as the square of the landing speed, one can reduce the bottom area of the boat in the same proportion, if the same favourable gliding angle of the boat's bottom is to be maintained. By this means the bending moments are also considerably reduced and the stress limit for the compressed members of the stiffening bulkheads is increased in a very similar proportion to that explained for the wing

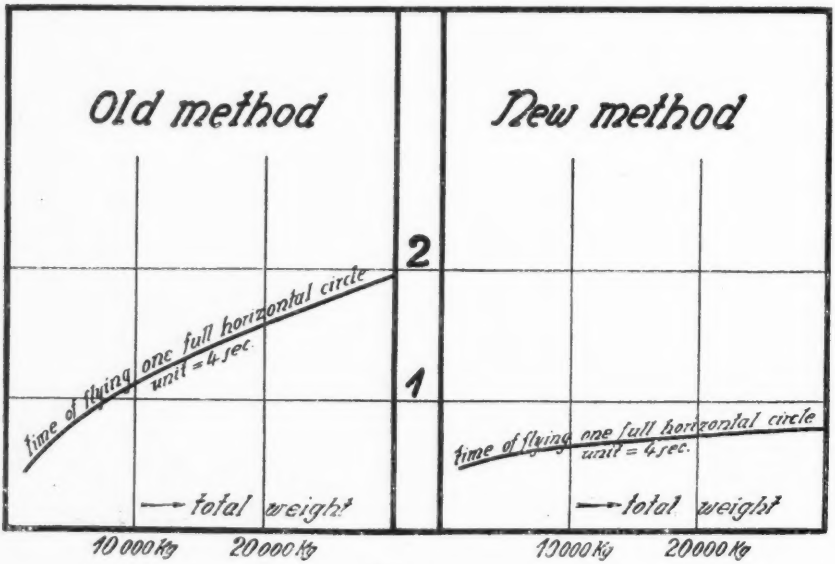

FIG. 4.

with high loading per square foot. The bottom of the boat has not only to withstand the normal stress during starting and landing on smooth water, but also the very heavy local shocks sustained by hitting the waves. The proportion between the stress caused through these local shocks and that caused by a normal start or landing on smooth water is more favourable for machines with high landing speeds.

With regard to the weight, it would be quite impossible to build a flat bottom for the large bottom of a boat with small landing speed. It would be necessary to give the bottom a distinct V-form, but this V-form has, according to our tank tests, a slightly greater water resistance and therefore a longer start than the flat bottom. The result is that the high wing loading, which makes the flat bottom possible, gives a very short start, and it has been proved by the short take-off time of the Ro II. that the high landing speed is no disadvantage for a properly designed boat, but it forms the basis of the greater advantage of a

very strong and robust boat structure which cannot be easily damaged by the eventualities of the flying service.

Another great advantage of the big machine with high wing loading is its better manœuvrability. Fig. 4 shows the time which is required for different machines of the same margin of power to fly the narrowest possible full circle without losing altitude. If big machines are built with small wing loading, the

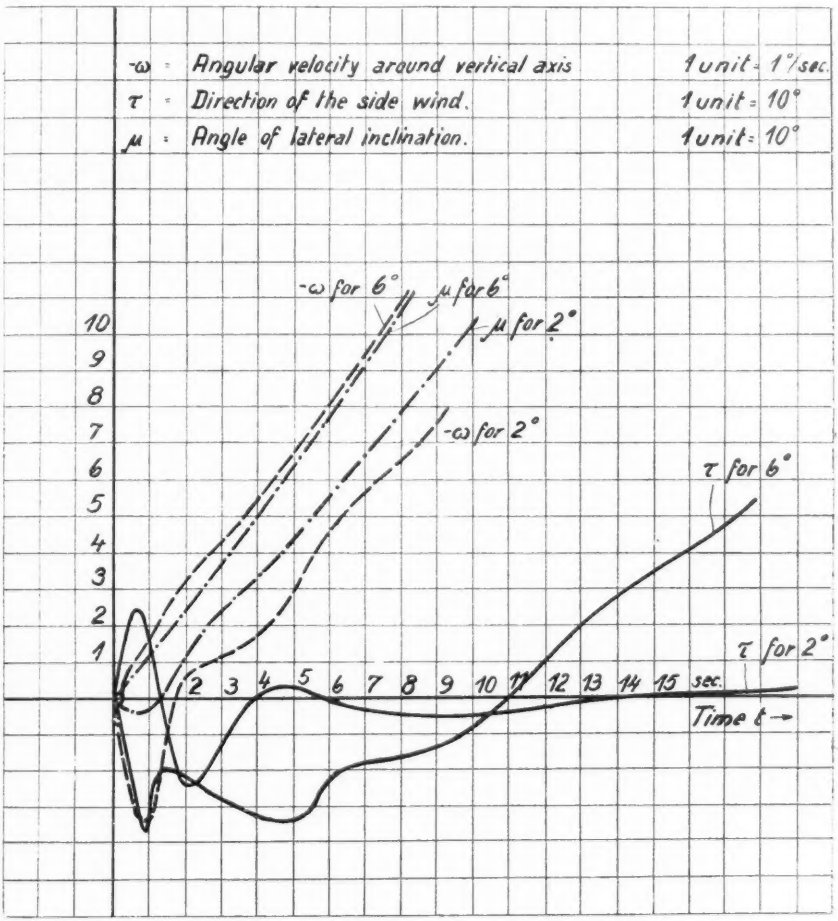

FIG. 5.

flying time for one full circle grows rapidly with the total weight of the machine, whereas in the case of the large machine with high wing loading the time required to fly a full circle is by far shorter.

It is true the greater wing loading means for the first time a more difficult task for the designer of a machine, because all factors of safety, pressures, and the working conditions of the controls and power plant are changed, so that these problems can only be satisfactorily solved by a great amount of scientific help.

It is quite obvious, however, that the principle of high wing loading is the one and only way for large seaplanes.

It is not sufficient that a machine should have the capacity of flying in very narrow circles, but it is necessary also that the time for putting a machine from a straight flight into the narrowest circle be as short as possible. The curves of

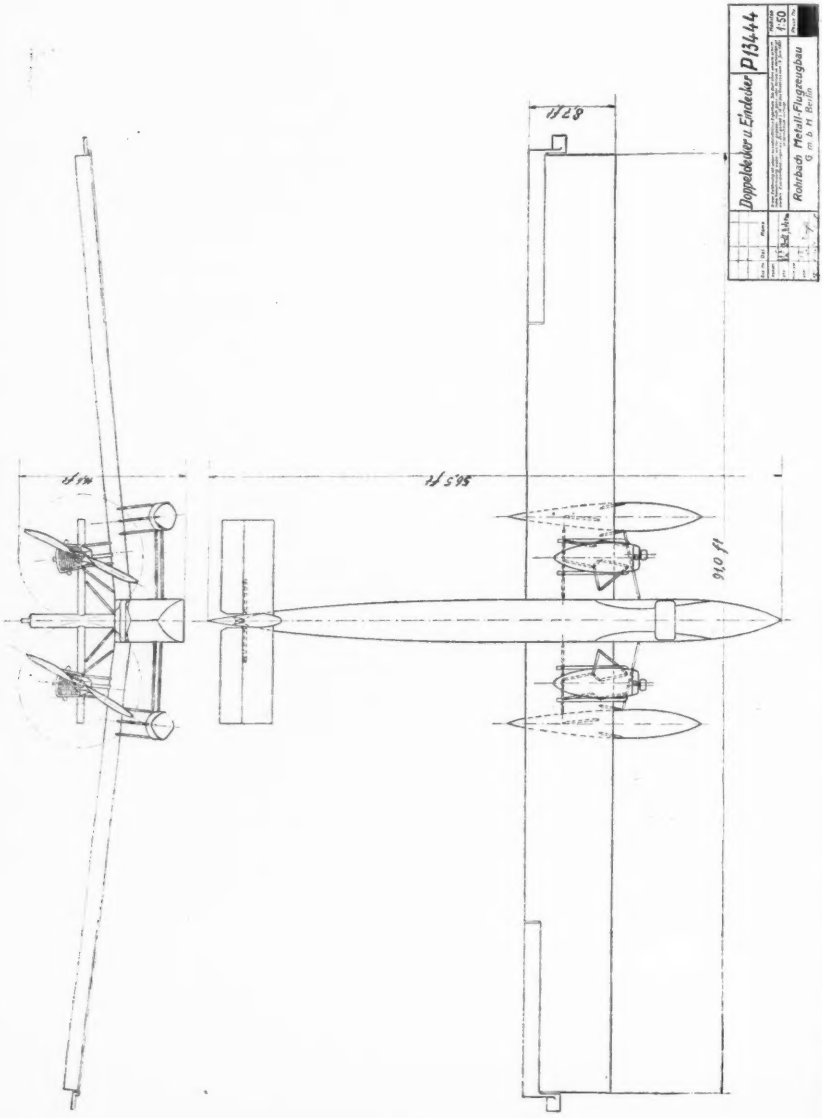

FIG. 6.

Fig. 5 show clearly that the curve controllability is much increased if the wings are given a sufficient dihedral. The curves given are for the dihedral angle 2° and 6°, and give the time which must elapse after a rudder setting of 15° and 2° aileron until a certain banking angle, a certain angular velocity and a certain deviation from the original straight course have been reached. This calculation has been made with the results of numerous model tests on the theory of small oscillations according to the theory and under supervision of Prof. Fuchs. The result has been fully confirmed by the results of the flying tests of the flying boat Ro II. This means for side and lateral controllability the same which has long since been known for longitudinal controllability. The machine with small longitudinal stability or instability is the most controllable. The high dihedral angle is the simplest means to give the machine such a very small amount of lateral instability that the highest curve controllability is obtained.

In the course of this calculation I have investigated the relative effect of the moment of inertia and of the dihedral angle on side controllability. The result has been that in the case of the flying boat Ro II. the effect of a 10 per cent. increased moment of inertia round the longitudinal axis is counterbalanced by an increase of the dihedral angle of 0.2°. Therefore the influence of the dihedral angle on the flying qualities is much greater than that of the moment of inertia. This, perhaps, also is an explanation of the experience that machines of the same type sometimes have rather different flying qualities, since a slight difference of

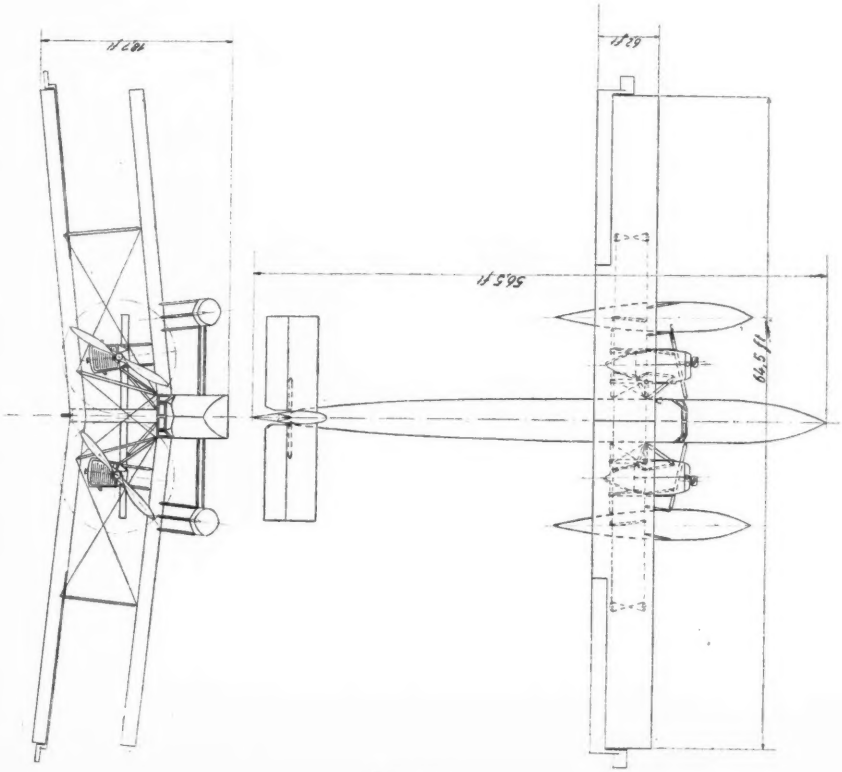

FIG. 6A.

the dihedral angle may easily escape unobserved and it has yet a very marked influence on side controllability.

The preceding consideration proved that the best type of machine is that made out of light metal with stressed skin, high wing loading and small lateral instability.

The next question was whether to build the machine as a biplane or monoplane. My general experience was very much in favour of the monoplane, because the number of connection points is smaller and the structure as a whole much more simple. In order to have clear comparison between both types, the preliminary design of the boat Ro II. was made in the form of a biplane and a monoplane. Fig. 6 shows a front and plan sketch for both types. Arrangement

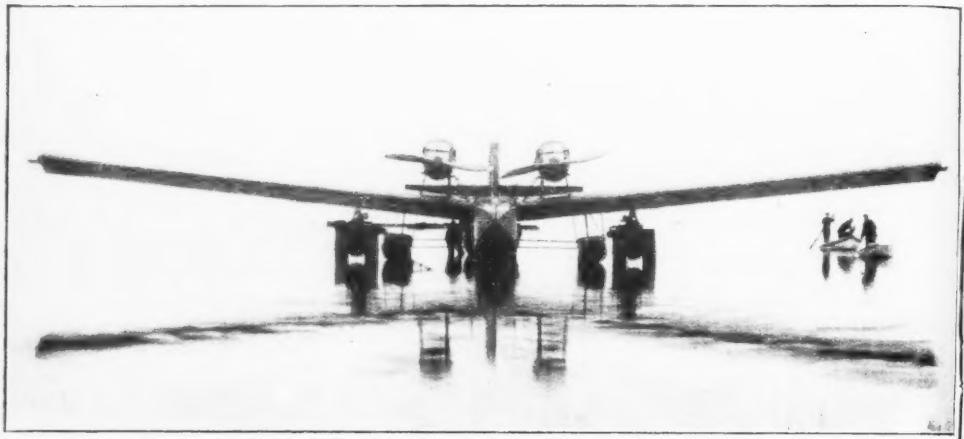

FIG. 7.

of power plant, hull, floats, tail unit, wing profile, the wing loading and power loading, and the factors of safety for flight and landing are the same for both monoplane and biplane. Therefore the difference in performance and dead-weight of both machines is exclusively due to the different qualities of the monoplane and biplane wing. The result is given in Table II., and shows that the dead-weight of the biplane structure without power plant is 300 kg., or about 13 per cent. lighter than that of the monoplane. The span is about 33 per cent. smaller than that of the monoplane. For the same total weight of 5,700 kilos, *i.e.*, for a 300 kilo higher loading of the biplane, the performance of the monoplane is by far better. The maximum speed of the monoplane is 117 miles and that of the biplane only 102 miles. The landing speed is the same for both machines owing to the equal wing loading. The ceiling of the monoplane is about 10,000ft., whereas that of the biplane is not more than 4,300ft. It is quite obvious that the biplane, owing to its low ceiling, is unable to fly the narrow curves that are so easy for the monoplane. One might say that this comparison is not quite correct to the last degree, because the tail unit of the monoplane and biplane should be a little different, and also on account of its low ceiling and correspondingly bad circling capacity the biplane could have a somewhat smaller factor of safety than the monoplane. On the other hand, the same propeller efficiency has been assumed for both types, whereas actually the propeller efficiency would be better with the faster monoplane. But all these neglections can never

make up for a gain of 15 per cent. of speed and 130 per cent. ceiling, and a corresponding amount of manœuvrability.

Fig. 7 shows the front view of the Ro II. type flying boat which is being built in Copenhagen. The width of the boat is only 4ft., and therefore, in order to obtain a sufficient amount of lateral stability, side floats of rather large size have been arranged on each side of the hull.

The distance between the two side floats is big enough to secure a very high lateral stability, and yet so small that the machine is not thrown out of its intended course in the water when one of the floats hits a big wave.

This arrangement combines, so to speak, the advantages of the twin-float machine and the flying boat, as it has the big lateral stability of the former, together with the great longitudinal stability and high seaworthiness of the flying boat.

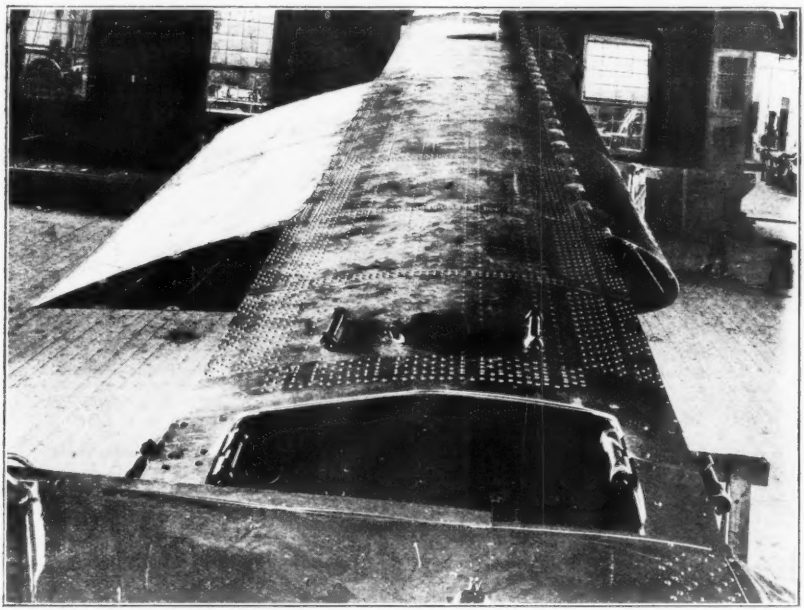

FIG. 8.

The vertical stresses upon these floats are transmitted to the wing by means of steel struts, and the horizontal shocks are taken by the steel struts which fix the floats directly to the side of the boat.

This form of float support relieves the wing root of any stress resulting from the horizontal forces which come on the floats through turning on the water when starting and landing in a direction which does not exactly coincide with that of the wind.

During the first part of the start the machine glides on both boat and floats, but as soon as a certain speed is reached the floats rise out of the water so that the last part of the start is made from the boat alone.

The specific pressure on the gliding bottom of the boat is about four or five times higher than is conventional with other boats.

In Fig. 8 is shown the arrangement of the wing structure. The whole stress is taken by the big hollow box girder.

The wing has its profile completed by means of nosepieces and trailing edge sections, which are fixed to the main girder by means of small bolts. Since the wing is not tapered, the nosepieces are interchangeable, and this also applies to the trailing edge sections.

The whole box girder may easily be inspected by turning back the fore or aft sections on their hinges, and should any section be damaged, it can easily be removed and replaced by another one.

The box girder is fixed to the hull by means of simple steel fittings and steel bolts.

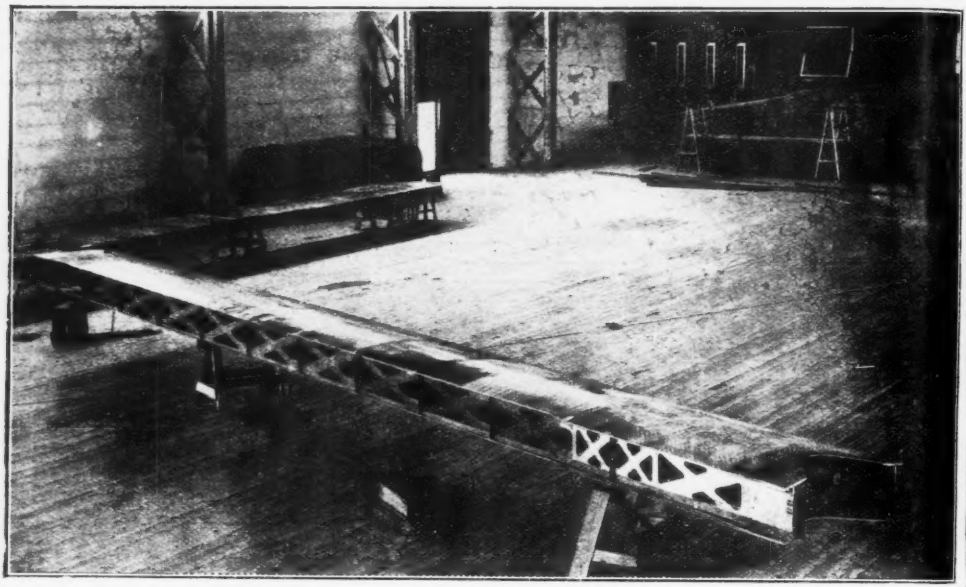

FIG. 9.

Fig. 9 shows the wing girder separated. The girder consists of the upper and under skin riveted together out of duralumin plates which go thinner and thinner from the wing root to the tip. These two skins are connected by means of duralumin angles with a front and rear web, and stiffening bulkheads are put in at certain distances from the hull to provide the necessary resistance against twisting.

Fig. 10 gives a photograph of the nose section of the wing during a test which was made in order to find the largest load that could be carried. This load was distributed by an arrangement of levers.

In Fig. 11 another nosepiece is represented. It is damaged by a sand test which was made to find out the local strength of its skin.

Fig. 12 shows a series of wing and sections on a jig, where the correct position of their fixing points is controlled so that they are interchangeable.

Fig. 13 gives the general arrangement of the whole machine. In order to secure the highest possible degree of manœuvrability on the sea, the engines were

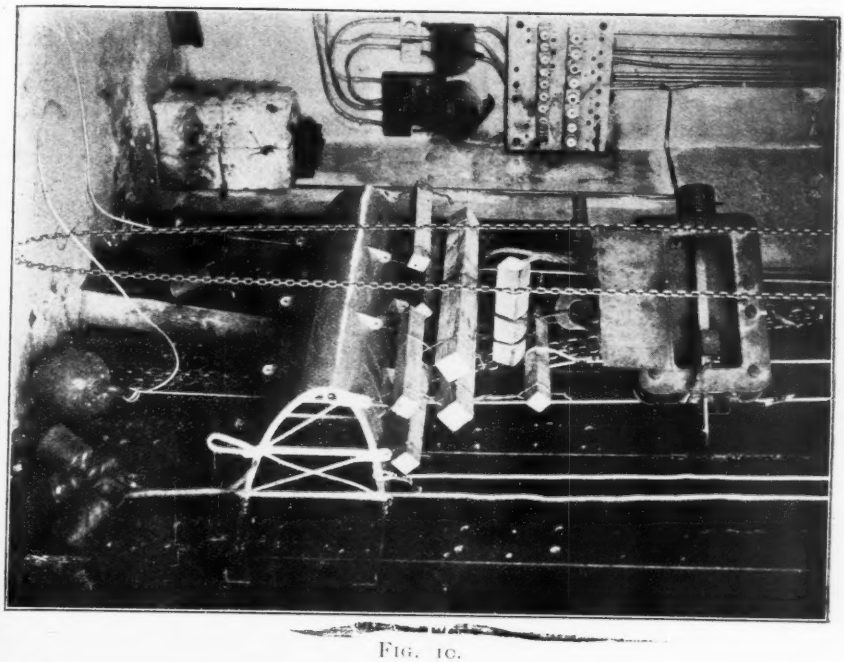

FIG. 10.

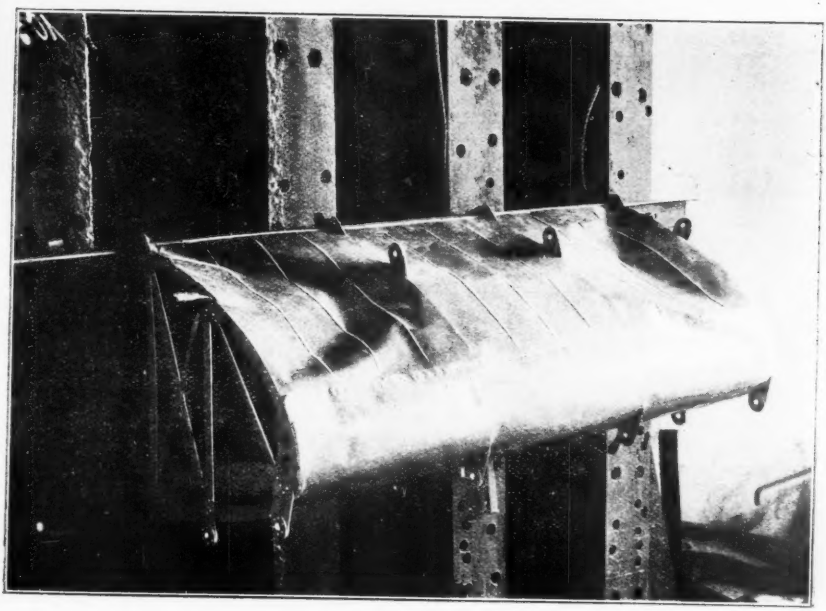

FIG. 11.

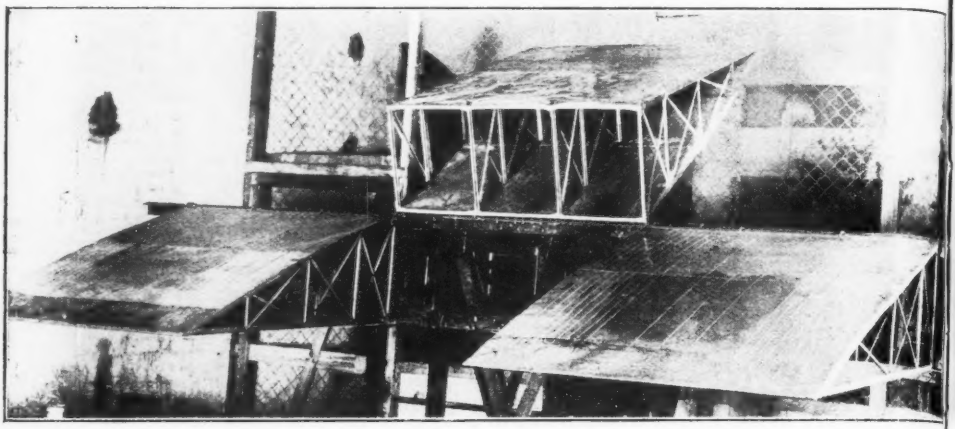

FIG. 12.

placed side by side; with this arrangement the machine could be turned out of the direction of the wind with great ease up to a wind velocity of forty miles.

In order to maintain a straight flying course in spite of the eccentric propeller thrust in the event of one engine failing during the flight, the whole tail unit can be swivelled up to a certain extent round the king post shown in Fig. 14. There is one bearing at the foot and another bearing at the top of this king post. The setting of the tail unit takes about five seconds and is operated by means of a crank near the pilot's seat, which by means of a chain and cables acts on a spindle, the nut of which is fixed to the nose part of the fin.

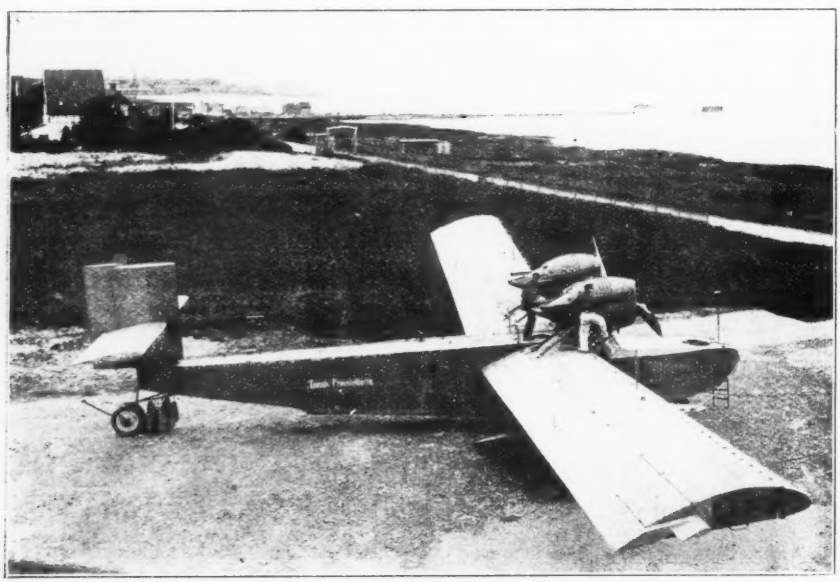

FIG. 13.

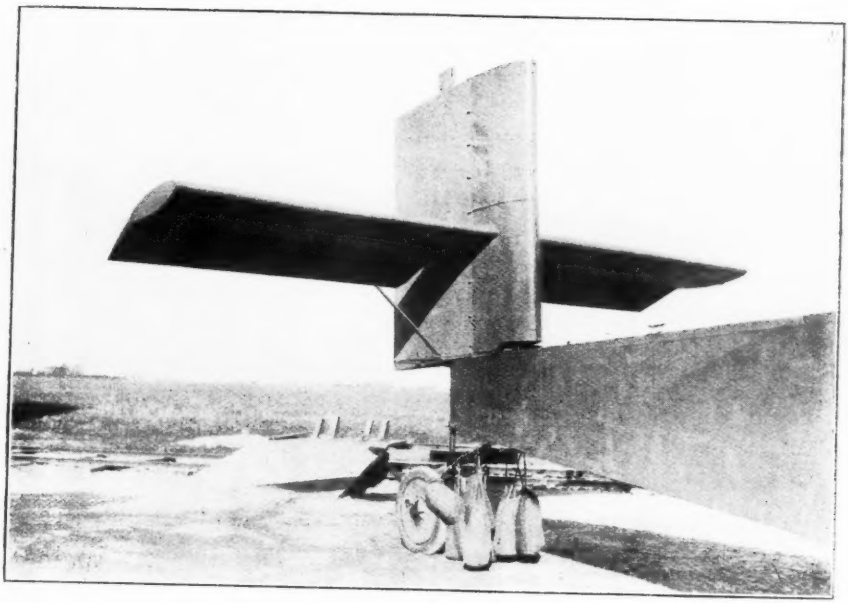

FIG. 14.

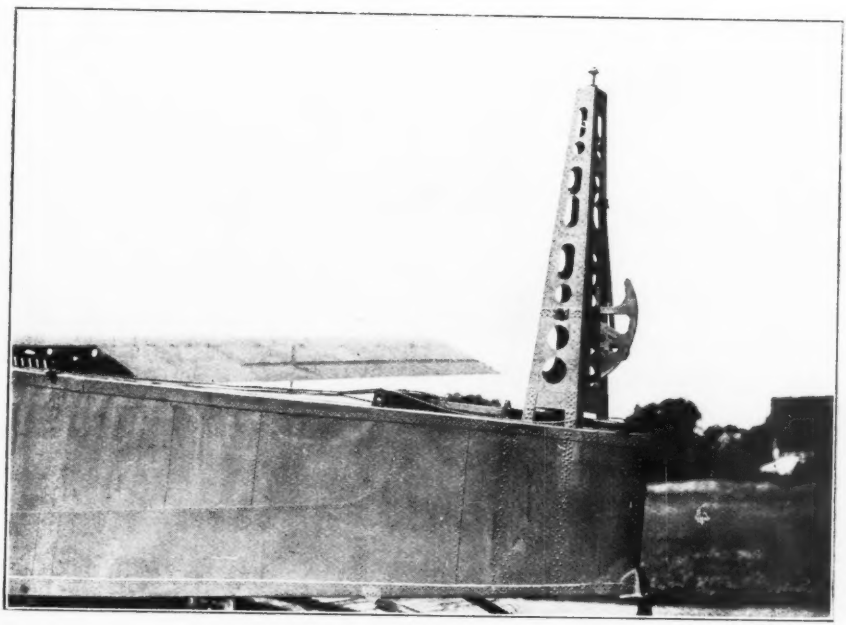

FIG. 14A.

It has been found very easy to fly in rather small curves against the eccentric thrust of either of the two propellers, and in my opinion the problem of flying on one engine has been definitely solved by means of this device.

It is theoretically quite clear and various flying tests have confirmed that aeroplanes can fly quite safely without losing altitude with a power loading of, say, up to 35 or 40 lbs. per h.p. as soon as they are in the air. But the difficulty was to fly a straight course because in most cases the thrust becomes eccentric as soon as one engine fails, and one has to use nearly all the possible rudder setting in order to maintain a straight course.

If under this condition the machine encounters a gust, it is thrown out of its course, and the speed being very small, the pilot has not enough rudder to bring

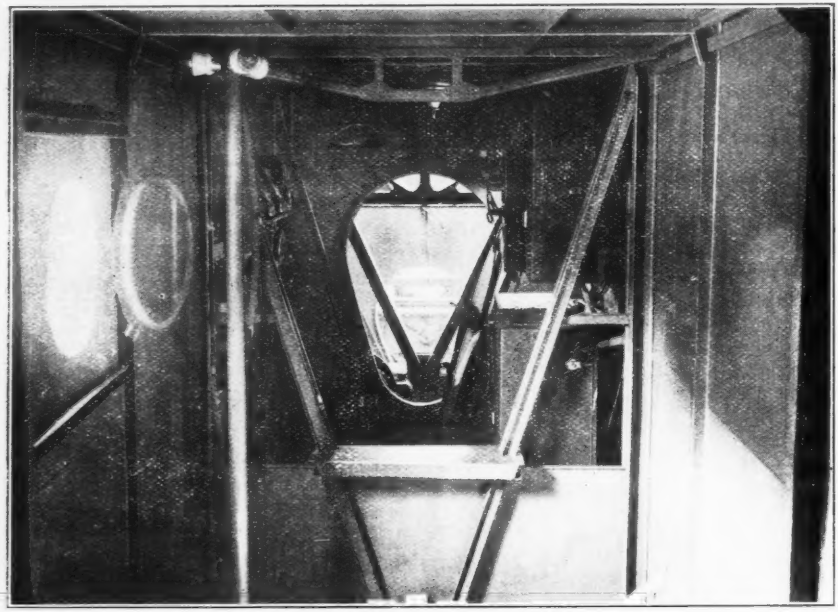

FIG. 15.

the machine back to its original course, unless he pulls his stick forward and sacrifices a certain amount of altitude in order to gain the additional flying speed which is necessary to increase the effect of the rudder.

In this way the loss of altitude in flying on one engine is, in my opinion, to a great extent a secondary effect of the non-sufficient rudder reserve, and pilots will learn to fly on one engine as soon as they are able to realise the advantages of setting the tail unit and can maintain their rudder bar in its normal position so that they have all their rudder setting at their disposal for maintaining the straight flying course.

I am sorry I have not yet had time to bring these tests to a definite conclusion, but all the preliminary tests gave very good results and fully confirmed this opinion.

Fig. 15 gives an inside view of the boat, showing very clearly the ship-building type of construction. They have five watertight bulkheads with doors

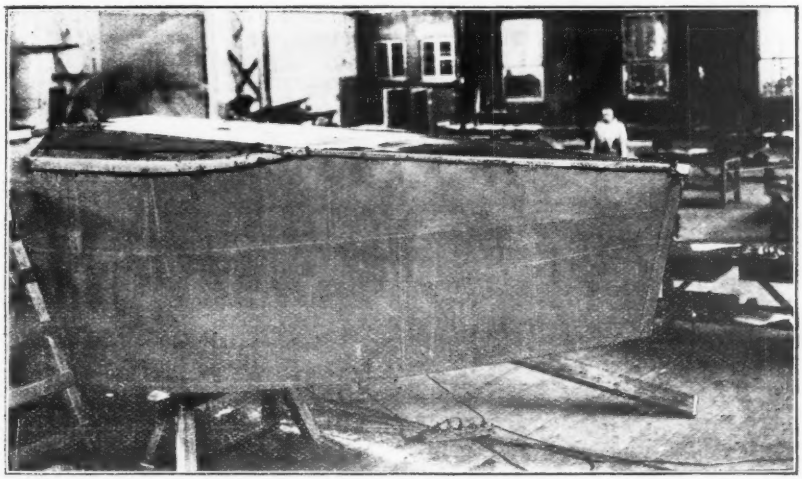

FIG. 16.

having a quick-closing arrangement, and these bulkheads are so arranged that any two compartments may be flooded without any danger with regard to the floating capacity or stability.

Fig. 16 gives a view of the front part of the boat, and shows the sharp ship-like bow and flat bottom of the boat as built at the present time and as the result of the experience gained with the first two machines.

Figs. 17 and 18 show the machine provided with provisional rigging of sails. It was very easy to turn the machine out of the wind with engine stopped

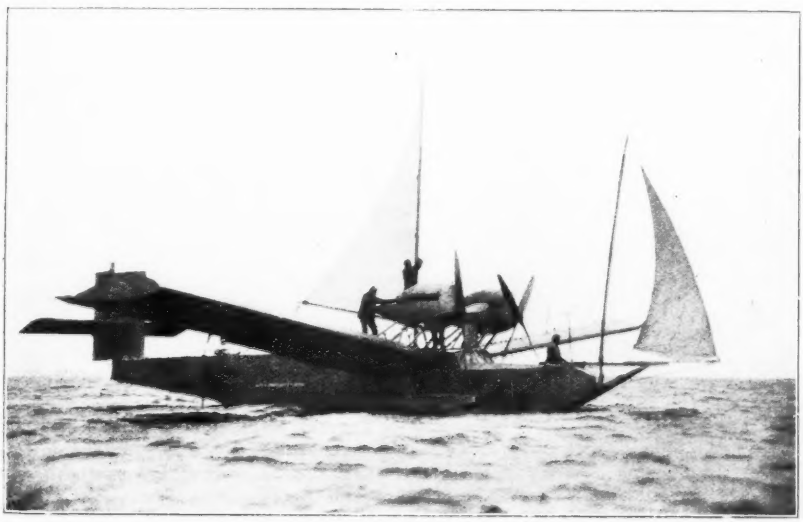

FIG. 17.

by means of the foresail alone. The sails had an area of 27 sq. metres, and with a wind of about sixteen miles per hour the machine sailed at about five knots. The control was very easily effected by means of a water rudder which can be easily fixed to the side of the hull near the rear cockpit and must be taken off before the starting. The machine did sail against the wind like any sailing vessel without too great a leeway, and the lateral stability proved to be so ample that it is intended to fit the next boats with a rather bigger sail area.

The masts will be of the telescopic type so that the sails can be put up and taken down in a very short time.

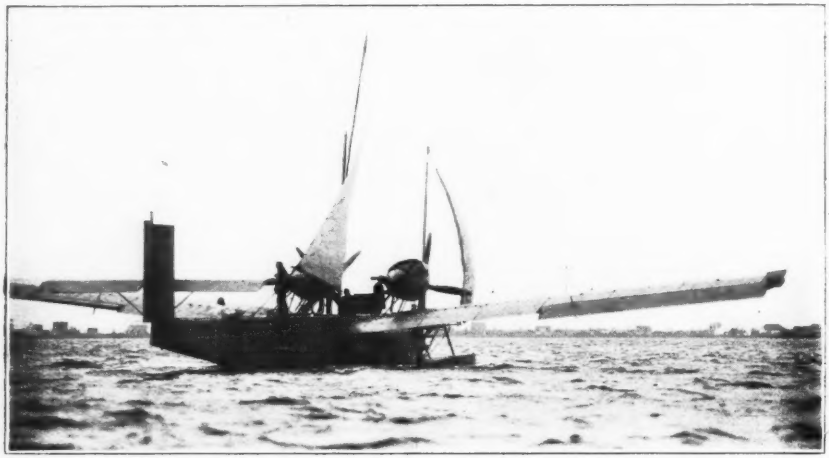

FIG. 18.

The extra weight of the whole rigging will be relatively very small and I think the flying boat will be very much safer through the use of these sails. If the engines cannot be used for any reason, the boat will be able to sail a great distance so as to reach some port or at least some part of the sea where ships are likely to be found.

DISCUSSION

Mr. MANNING, who opened the discussion, said he felt sure that all those present would have appreciated the lecture, which was of special interest, because of the totally different lines on which Dr. Röhrbach had been working from current English practice. He had one or two questions he would like to ask. The plan form of the wings of Dr. Röhrbach's seaplane he noticed were rectangular. This had rather surprised him as the taper form of wing had certain structural advantages, such as the reduction of the bending moment and was a lighter form of construction. On the other hand, of course, it was more costly to produce.

He would like to know whether Dr. Röhrbach experienced serious corrosion with duralumin or whether he took any special precautions to avoid this, and whether he had any torque trouble with the monoplane wings or found any wing flutter. He would have thought that when the machine was moored in a heavy wind with the tide against the wind there might be trouble with so large a dihedral angle. Difficulties might also arise when the machine was being

manœuvred on the water in a wind. Such points as these could, however, only be definitely settled by experience.

Mr. NORTH was afraid that not having had an opportunity of seeing Dr. Röhrbach's paper in advance it was rather difficult to express an opinion on the arguments he put forward for the large aeroplane with increased wing loading, but there were one or two points which Dr. Röhrbach might clear up in order to assist them in understanding the paper. Firstly, it had not been made clear whether in altering the wing loading the span had been altered. If the span were unaltered the induced drag would remain the same. He presumed that one of the objects of increasing the loading would be to reduce the bending moment and so would have inferred that the span would be reduced, but from the pictures of the machine he gathered this was not the case. In regard to the comparison between the monoplane and biplane forms of wing, if they both had the same span and the area and profile drag remained the same, the induced drag of the biplane would be rather less. He thought that the statement that the monoplane was more efficient than the biplane required some qualification. Dr. Röhrbach had stated that the increase of power in the case of the more heavily loaded aircraft was due solely to increase in speed, the thrust remaining the same. In view of the fact that power expended on the parasite and profile drag increases as the cube of the velocity, he did not quite understand this.

It was an extremely interesting and valuable lecture which had been given them. As an engineer he particularly appreciated the admirable way in which the assembly of the aeroplane fitted in with the conception. In his opinion Dr. Röhrbach had not enumerated all the advantages he might have claimed for his seaplane. There was no doubt that in the particular machine he had shown he had accomplished a very remarkable engineering feat.

Flight-Lieutenant LUCKING said he was personally very grateful to the lecturer for his most stimulating paper. There were, however, one or two points he would like to mention that might be of interest to those present. He thought some members might not be acquainted with the fact that seaplanes of the usual wooden construction absorbed an enormous amount of water. He had made some special tests with regard to this and found that a flying boat with a total weight of 18,000 lbs. absorbed 600 lbs. of water, which could not be accounted for by any that could be seen. It lay in film fashion over everything, and was soaked in. He weighed this machine after it had been in the shed in dry weather, and again after it had been lying out on the water in foggy weather, and had found this extraordinary difference, which had been confirmed in tests with another boat. He thought this was one of the most striking arguments in favour of the all-metal seaplane. All-metal construction was thus even more justified in the case of seaplanes than landplanes.

Another point that had struck him particularly was the high wing loading of the Copenhagen machine. From experience here it had been found that low wing loading was extremely helpful in getting off and landing in a bad sea owing to the low minimum flying speed. He thought that most of the members who remembered the Short 184 would recall how her very low wing loading enabled her to get off a comparatively bad sea. He thought unless one had extremely high h.p. for weight, so that acceleration was very good, it would be difficult to take off a heavily loaded machine in a bad sea. In landing also, he thought that a high speed contact with rough water would be dangerous.

Wing-Commander T. R. CAVE-BROWNE-CAVE asked whether the arrangement of a hull and two side floats allowed the machine to ride comfortably on a broken sea. One of the advantages one would expect with a very big dihedral angle was that the wings would be very unlikely to get damaged in a bad sea. The base in Dr. Röhrbach's design was so much narrower than that of a flying boat with wing tip floats that there appeared to be danger that wind under one wing would

blow the other down and cause damage. If Dr. Röhrbach would tell them of his experiences on this point it would be of great assistance.

In the design of a metal hull one naturally tried to avoid a flat under-surface. He had noticed that the only part of the bottom of the hull he could see in the photographs was dead flat. He was sure that Dr. Röhrbach had reasons for this and he would like to hear of the experiments that had led him to that surprising conclusion.

REPLY.

In replying to the discussion, Dr. Röhrbach said that he entirely agreed with Mr. Manning regarding tapered wings, but they were too expensive, on account of the very high expense for jigs, which are necessary with regard to the accuracy of metal construction. If machines were built in quantities they might go to tapered wings, which would result in a saving of weight of 2 or 3 per cent.

With regard to protection of duralumin from sea water, he could only say that, if everything was carefully done and material of the same analysis was used for the rivets and plates and protective paint was used, there was no difficulty at all. Even if the protective paint was damaged for some time no serious corrosion occurred. It was necessary to have protective paint in all those places where different plates were in contact. They must be either electrically isolated or protected from the intrusion of the sea water by protective paint.

The torque question with the monoplane was found a great difficulty. It had taken some three years to overcome it with a very great number of structural model tests. To-day they were able to calculate the strength and to put the material where it was wanted and remove it where it was not needed. The agreement of calculations with practice was within 3 to 5 per cent., which was quite close enough. The wing was remarkably stiff against torsion and had not shown the slightest tendency to flutter.

Of course the big dihedral increased the moment about the longitudinal axis, but it was only necessary to increase the distance between the boat and the side floats very little to obtain a big increase in lateral stability during flotation and he had found no difficulty with the present arrangement.

With regard to Mr. North's inquiries, he was sorry that he had not sufficiently explained the comparison between heavily loaded and lightly loaded wings. The machines had all the same aspect ratio and profile with correspondingly reduced dimensions. The wing loading was increased by making similar but geometrically smaller wings, though of course in practice there were a few minor differences.

The calculations of weight were made on the assumption of a factor of safety of five for a type of wing construction which was a little less efficient than that now used.

The increase in power was, of course, and as already mentioned in the lecture, not quite proportional to the increase of speed with higher wing loading. The effect of skin friction is also to be considered, but all these influences when calculated were relatively minor compared to the higher speed which corresponds to the higher wing loading with the same relative margin of power.

The span of the biplane was in my comparison smaller than that of the monoplane. If the span of the biplane had been increased its performance would have been better, but then the dead-weight would have been heavier.

With regard to Flight-Lieutenant Lucking's remarks, he thought that ease of getting off in heavy seas depended on whether the shape of the bottom of the hull was carefully and successfully adapted to the wing loading. There must be

a certain angle of incidence in the gliding part of the bottom of the hull. If the bottom of the hull were not suitably adapted to the wing loading the gliding angle of the bottom would be unfavourable and the getting off in a heavy sea very difficult. There was really no difference between the start of a heavily loaded and a not so heavily loaded machine.

He thought that the flat bottom had the advantage of better water resistance when gliding. The bottom from the first step forward was quite flat.

Dr. Röhrbach then referred to the question of the relative merits of steel and duralumin construction. He said that Mr. North's recent lecture on that point had dealt with it so completely that not much more could usefully be said. It depended on the kind of steel employed. One could use such a strong steel that it was lighter, but there were other difficulties to consider. He preferred plates of duralumin.

In reply to Wing-Commander Cave-Browne-Cave, he said that experiments with lateral stability in a heavy sea were not yet finished. The machine had been flown and manœuvred in a sea of force three or four with a wind of 15 metres per second. Under these conditions it was quite easy to turn the machine out of the wind and the lateral stability was such that the leeward wing with its dihedral angle of six degrees was not even horizontal. In his opinion, therefore, it was quite impossible that the leeward wing should ever hit the top of any wave and he thought that this type of flying boat was by far the most seaworthy machine that ever floated on the sea.

Colonel OGILVIE congratulated the Society that Dr. Röhrbach had courage enough to come over here and tell them a great deal of what he knew about metal seaplane construction and also to speak in a language which was foreign to him. The same courage was to be seen in the design of the machine which struck him as being extremely sound. The disadvantage of the two-float and single-float systems was well known and until more experience had been gained with Dr. Röhrbach's three-float arrangement he did not think it possible for anyone to say that it was the best.

What struck him as the most remarkable was the fact that the bottom of the boat was flat. In this country the idea of a flat bottom had been discarded. A V-bottom was used of which the angle had tended to get more and more sharp.

He expressed his agreement with the suitability of high wing loading for seaplanes. The difficulties of high wing loading with land machines were well known, but he thought that the only chance of building a successful large seaplane was to have a high wing loading.

He thanked Dr. Röhrbach in the name of the Society for coming over and giving so admirable a lecture, which would be of great assistance and provide a great stimulus to designers here.

PROCEEDINGS

Third Meeting, 60th Session.

A meeting of the Royal Aeronautical Society was held in the Society's Library at 7, Albemarle Street, London, on Thursday, October 30th, 1924, when a paper on "The Royal Aero Club Light Aeroplane Competitions" was read by Major J. S. Buchanan, Associate Fellow. Lieutenant-Colonel H. T. Tizard, A.F.C. (Chairman of the Society) presided.

ROYAL AERO CLUB LIGHT AEROPLANE COMPETITIONS

BY MAJOR J. S. BUCHANAN, A.F.R.AE.S.

I am indebted to the Air Ministry for permission to use the material contained in the various official reports dealing with this subject, and I wish to say that the views expressed in this paper are my own personal views and do not in any way represent the official view of the Air Ministry, nor indicate the policy to be pursued.

I am also indebted to the makers of the aircraft for supplying information in such detail and for permission to make use of this information.

In dealing with a paper of this description, it is appropriate that some reference should be made to the origin of the light aeroplane, and for this reason I have begun with a short outline of the inception and development of a type of aircraft which may have an important effect on the future of aviation.

The success achieved in Germany in gliding with aeroplanes without a power unit during the years 1921-22 aroused great interest in this country and led to extravagant statements being made as to the future of this type of aviation.

The "Daily Mail" offered a considerable prize for a competition between aircraft of this type, and trials were carried out, under the control of the Royal Aero Club, at Itford in September, 1922. A considerable measure of success was achieved in gliding on the ridge at parts where the up-currents of air provided the power required to overcome the force of gravity. As is well known, the prize was won by M. Maneyrol on a Peyret glider.

Immediately following these tests, about October, 1922, Mr. Manning of the English Electric Company put forward to the Air Ministry a proposal to construct a small aeroplane fitted with a 3½ h.p. A.B.C. engine. A contract was made, and one aeroplane was designed and built by this firm. This was flown successfully by Squadron Leader Wright in April, 1923. Whilst it was clear from consideration of the aerodynamics of the design that an aeroplane of this type would fly satisfactorily, it was considered doubtful if there would be sufficient power to get off the ground without external aid. Arrangements were made for catapulting if this fear proved well founded. As events turned out, the initial flights showed that there was sufficient power available to enable the aeroplane to take off even in a calm.

About December, 1922, Major Gnosspelius and Mr. Lancaster-Parker commenced the design of the Gull aeroplane, which was fitted with a 750 cc Blackburn engine. This type was novel in its design, and followed the lines indicated by the model tests carried out by the designer at Rochester, using the pendulum method.

Early in 1923 the Duke of Sutherland, then Under-Secretary of State for Air, offered a prize of £500 for a competition between light aeroplanes, as they had now come to be called, to be held toward the end of 1923, with engines not exceeding 750 cc capacity.

The "Daily Mail" again came forward and offered £1,000 for the same purpose. The conduct of the competition was undertaken by the Royal Aero Club. Further prizes were subsequently offered for reliability, altitude and speed tests.

The view held by even the most competent technical opinion on the possibilities of this type of aircraft is indicated by the great care which was taken to select a suitable site for this competition. Finally, Lympne Aerodrome was selected, and the selection was certainly influenced by the presence of a ridge of hills near the aerodrome which would facilitate gliding on up-currents and assist flight. No doubt competitors obtained considerable assistance from such currents.

The competition was held in October, 1923. An extract of the conditions of the tests is given in Appendix I.

Table I. gives a list of the aeroplanes which appeared at Lympne for these competitions and gives their general aerodynamic characteristic as well as the performance measured during the tests. Table II. is a summary of the detail weights of each type of aircraft, so far as I have been able to obtain these in the time at my disposal. I have endeavoured to make these as accurate as possible, but it is always a matter of great difficulty to get such figures reduced to a truly comparative basis. They are about as accurate as any other comparative weight schedule.

The engines used were motor-bicycle engines not designed for aircraft use, and whilst many detailed troubles were experienced, the engines, on the whole, ran very well.

In general, the most reliable power units were those in which the propeller was driven directly off the crankshaft. In those cases where a chain drive was used, the drive gave considerable trouble, and prevented any reasonable comparison being made of the relative efficiency of geared and ungeared drives for the propeller.

The Sargant engine, fitted to the Peyret and the Poncelet monoplanes, had a $2\frac{1}{2}:1$ helical spur gear drive to the propeller, but the amount of flying done by this engine was insufficient to furnish a real test of its relative efficiency.

The loading per h.p. varied from 17.7 to 60, but the majority of the types were in the neighbourhood of 30-35 lbs. per h.p.; these figures are approximate only, since the available information with regard to engine power and r.p.m. actually used was scanty. Generally speaking, it might be said that the h.p. loading of 30-35 lbs. per h.p. gave sufficient power for reasonable flight with the wing loading employed.

From the number and character of the forced landings which took place during this competition it would appear that lighter-loaded types—that is, types with a wing loading of about 4 lbs. per sq. ft.—could make a forced landing in a restricted area at least as easily as aeroplanes with a larger reserve of power.

Of the fifteen aircraft flown, only three were biplanes, and these were seriously handicapped by engine trouble during the whole week. For this reason it is difficult to estimate the comparative merits of monoplanes with biplanes in the air for this class of aircraft. Both types were quite satisfactory in the air.

From a constructional point of view the majority of the aircraft had been carefully designed, and whilst it is true that the scantlings of the parts were rather fine, no trouble in this direction was revealed during the week's flying.

At the same time, it must be admitted that in the majority of cases the size of the members was unsuitable for any sort of rough handling.

As regards the wings, the great range of aerofoil sections used showed that there was a considerable divergence of opinion on the best type of aerofoil for this type of aircraft. The figures available from the tests do not show that any particular type of aerofoil was markedly superior to any other. Various wing arrangements were employed and various methods of spar construction, but there was no radical departure from what is considered standard practice.

Three-ply was largely used in the construction of fuselages, even in some cases to the extent of using three-ply gusset plates in place of the usual metal fittings.

On the whole, the landing gears could not be considered satisfactory, with the exception of the D.H.53 " Viget " and possibly the Parnall " Pixie." The undercarriage of the " Pixie " was of a novel type, and depended for its shock-absorbing capacity on the resilience of the axle and the tubular struts. Experience over this past year has shown that this type of undercarriage gives reasonable service. It was apparent that small wheels inside the fuselage were not suitable for general work, particularly as it involved a small angle on the ground, and therefore a long run to get off and land, as well as rendering the fuselage liable to accidental damage. On some machines larger wheels were fitted, and these in general were the more satisfactory.

With regard to the control surfaces, it was to be expected that these would be proportionately larger than those in common use on ordinary aircraft, bearing in mind the slow flying speeds of these light aeroplanes, and the experience at Itford on gliders the preceding year.

Some of the aeroplanes taking part in this trial were purchased by the Air Ministry. So far only three of these have been tested at Martlesham, and the results of these tests are given in brackets in Table I. Further types are still to be delivered.

In addition to this, six of the D.H.53 type were purchased and sent to various R.A.F. units for general test. These have been flown by a large number of R.A.F. officers and are standing up to ordinary service use in a satisfactory manner. The 750 cc " Blackburn " is fitted to these aeroplanes.

It is difficult to assess the results of this competition. It can be said at once that there was nothing in any of the aeroplanes which could be called new, either structurally or aerodynamically. On the other hand, the aeroplanes exceeded expectations in performance, as will be seen from the figures in Table I. They got off the ground easily and flew comfortably at 30-35 lbs. per h.p., and in one case at 60 lbs. per h.p. In my opinion these results can be attributed only to clean design and to the greatest care of the details of construction. The aerodynamic efficiencies of these aircraft are high, and I regret that sufficient test information is not yet available to give exact figures on this point. One of the types tested (the Gull) has an efficiency KL/KD of about 14 to 1, and it is possible that some of the others may have higher efficiencies. This compares very favourably with the efficiencies KL/KD of military and civil types which are of the order of 5/1 to 8/1.

One factor which may contribute to this improved efficiency is that the engine exerts very much less influence on the design than is the case with what we may call normal aircraft. You will see from Table II. that the power unit percentage is small, but further than that the engine is of such a size as to fit easily into any fuselage capable of accommodating a man. For this reason, as well as the absence of extraneous equipment, a clean fuselage line is possible.

At the close of the tests the Under-Secretary of State for Air announced that the Air Ministry would offer a substantial prize for a two-seater dual control

			Power Unit.		
Contractor.	Aircraft.	Type.	Engine.	H.P. at R.P.M.	Pr
Air Navigation and Eng. Co.	A.N.E.C.	Braced High Wing Monoplane	694 c.c Blackburne	26 at 3800 15 at 2500	
A. V. Roe and Co.	Avro Type 558	Biplane	500 c.c. Douglas	17 at 4000	Cha
A. V. Roe and Co.	Avro Type 560	Cantilever High Wing Monoplane	694 c.c. Blackburne	15 at 2500	
De Havilland Aircraft Co.	D.H. 53	Braced Low Wing Monoplane	750 c.c. Douglas	15 at 2500	
Gloucestershire Aircraft Co.	Gannet	Biplane	750 c.c Carden (2-stroke)	13 at 2200	
Short Bros.	Gull	Braced High Wing Monoplane	694 c.c. Blackburne	26 at 3800	Chai 2 a
Air Navigation and Eng. Co.	Handasyde	Braced High Wing Monoplane	750 c.c. Douglas	15 at 2500	
Handley Page	H.P.	Cantilever High Wing Monoplane	400 c.c. A.B.C.	8 at 3000	
R.A.E. Aero Club	Hurricane	Cantilever High Wing Monoplane	600 c.c. Douglas	20½ at 4000	Cha 2
L. Peyret	Peyret	Braced High Wing Monoplane	750 c.c. Sergant	15 at 3200	Sing sp 2
Geo. Parnall and Co., Ltd.	Pixie I.	Braced Low Wing Monoplane	500 c.c. Douglas	13 at 3000	Chai
Geo. Parnall and Co., Ltd.	Pixie II.	Braced Low Wing Monoplane	750 c.c. Douglas	26 at 5000	Chai
—	Poncelet	Cantilever High Wing Monoplane	750 c.c. Sergant	15 at 3200	Sing sp 2
Vickers, Ltd.	Viget	Biplane	750 c.c. Douglas	19 at 3400	Chai
English Electric Co., Ltd.	Wren	Cantilever High Wing Monoplane	398 c.c. A.B.C.	7 at 2500	

TABLE I.

TRIALS AT LYMPNE, 1923 (SINGLE SEATERS).

it.		Loading.								Aerod
P.M.	Prop. Drive.	Lbs. Wt. Empty.	Lbs. Wt. Loaded.	Lbs./H.P.	Lbs./sq. ft	Length Overall.	Ht. on Ground.	Span.	Mea Cho
800	Direct	290	470	18.1	3.24	15′ 7″	4′ 9″	32′ 10″	4′
500				31.3					
000	Chain 2½ to 1	298	483	28.4	2.91	19′ 8½″	6′ 9″	30′ 0″	3′
500	Direct	286	471	31.4	4.28	21′ 0″	4′ 9″	30′ 6″	4′
500	Direct	310	490	32.7	4.08	19′ 8½″	5′ 0″	30′ 1″	4′
200	Direct	248	440	33.9	4.07	16′ 8″	6′ 0″	18′ 0″	3′
800	Chain 1.61 to 1 2-pusher airscrew	360	540	20.75	3.29	20′ 10″	4′ 4″	36′ 2″	5′
500	Direct	300	500	33.4	3.7	19′ 2″	4′ 3″	30′ 0″	4′
00	Direct	274	450	56.3	2.84	21′ 3″	4′ 2″	36′ 6″	4′
000	Chain about 2 to 1	375	564	27.5	7.05	16′ 0″	4′ 7″	23′ 0″	3′
200	Single helical spur gear 2½ to 1	330	515	34.4	3.14	18′ 3″	5′ 6″	32′ 4″	4′
000	Chain 2 to 1	276	457	35.1	4.57	18′ 0″	4′ 8″	29′ 0″	4′
000	Chain 2 to 1	279	460	17.7	7.67	18′ 0″	4′ 9″	17′ 10″	4′ ma
200	Single helical spur gear 2½ to 1	490 425	690 625	46.0 41.6	2.80 2.98	21′ 6″ 21′ 6″	— —	— 36′ 6″	
00	Chain 3 to 1	300	570	30.0	2.85	17′ 4″	7′ 1″	25′ 0″	4′
00	Direct	232	420	60.0	2.90	24′ 3″	4′ 6″	37′ 0″	3′

TABLE I.

TRIALS AT LYMPNE, 1923 (SINGLE SEATERS).

Prop. Drive.	Loading. Lbs. Wt. Empty.	Lbs. Wt. Loaded.	Lbs./H.P.	Lbs./sq. ft	Aerodynamic Features. Length Overall.	Ht. on Ground.	Span.	Mean Chord.	Area sq. ft.	Aerofoil Section.	Aspect Ratio.	Performance. Speed Range M.P.H.	Top Speed M.P.H. Trials.	Economy M.P. Gall.	Endurance Miles.	Altitude Feet.
Direct	290	470	18.1 31.3	3.24	15′ 7″	4′ 9″	32′ 10″	4′ 5″	145	Thick dev. by designer	7·44	32-80	74	87·5	775	14,400
Chain 2½ to 1	298	483	28.4	2.91	19′ 8½″	6′ 9″	30′ 0″	3′ 0″	166	R.A.F. 15	10.44	30-60	—	—	50	13,850
Direct	286	471	31.4	4.28	21′ 0″	4′ 9″	30′ 6″	4′ 1″	110	Thick dev. by designer	8.86	34-65	—	63.3	1000	—
Direct	310	490	32.7	4.08	19′ 8½″	5′ 0″	30′ 1″	4′ 3″	120	Thickened R.A.F. 15 varying thickness	7.08	36-65	57·5	59·3	375	—
Direct	248	440	33·9	4.07	16′ 8″	6′ 0″	18′ 0″	3′ 1½″	108	Thickened No. 64	5.98	Engine trouble prevented flying.				
Chain 1.61 to 1 2-pusher airscrew	360	540	20.75	3.29	20′ 10″	4′ 4″	36′ 2″	5′ 0″	164	Approx. R.A.F. 14 with step dev. by designer	7·92	38-65	55.25 69.0 M'sham.	—	37·5	—
Direct	300	500	33·4	3·7	19′ 2″	4′ 3″	30′ 0″	4′ 11″	135	Göttingen 422	6.2	30-65	—	65·7	158.5	—
Direct	274	450	56.3	2.84	21′ 3″	4′ 2″	36′ 6″	4′ 3″	158	No. 64 increased to 12% camber	7.2	25-30	—	—	37·5	—
Chain about 2 to 1	375	564	27·5	7.05	16′ 0″	4′ 7″	23′ 0″	3′ 9¾″	80	Göttingen 420 Rev. 396 436 428 Tip.	6.04	42-75	58.5	—	25.0	—
Single helical spur gear 2½ to 1	330	515	34·4	3·14	18′ 3″	5′ 6″	32′ 4″	4′ 9″	164	Unknown thick section	6.4	28-65	—	—	—	9,400
Chain 2 to 1	276	457	35·1	4·57	18′ 0″	4′ 8″	29′ 0″	4′ 2″	100	R. & M. 322 varying thickness	6.22	36-65	—	53·4	125	—
Chain 2 to 1	279	460	17·7	7.67	18′ 0″	4′ 9″	17′ 10″	4′ 7″ max.	60	R. & M. 322 varying thickness	3·9	45-90	76.1	—	—	—
Single helical spur gear 2½ to 1	490 425	690 625	46.0 41.6	2.80 2.98	21′ 6″ 21′ 6″	— —	— 36′ 6″	— —	247 210	Fokker type	— —	32-65 —	— —	— —	— 75	— —
Chain 3 to 1	390	570	30.0	2.85	17′ 4″	7′ 1″	25′ 0″	4′ 3″	200	R.A.F. 15	6.01	30-65	58.1 49.0 M'sham.	—	50	—
Direct	232	420	60.0	2.90	24′ 3″	4′ 6″	37′ 0″	3′ 11½″	145	T. 64 varied	9·37	25-49	—	87·5	362.5	—

aeroplane to be competed for in 1924. After some discussion, the size of the engine was fixed at a maximum value of 1100 cc volume swept. There was, and there still is, considerable divergence of opinion as to the size of engine required for this type of aeroplane, but it was felt that an engine of this size would give a satisfactory performance when fitted to an aeroplane for competition purposes.

It was considered that the experience of the 1923 tests had shown that petrol consumption was relatively a small proportion of operational costs, and for this reason it was decided not to introduce a petrol consumption test in the next year's competition.

The main object of the new competition was to produce a dual control light aeroplane suitable for use by both official and unofficial bodies, and to ascertain to what extent the cost of flying could be reduced. The rules were therefore framed round the following features:—

1. Speed range.
2. Distance to get off and land.
3. Reliability.

Each aeroplane, prior to the competition, was required to demonstrate that it was in fact a dual control aeroplane and could be flown from either seat. An extract of the conditions of the competition is attached as Appendix II.

The Royal Aero Club again consented to organise and carry out this competition, and Lympne Aerodrome was selected as the site.

The competition commenced on September 27th, 1924. In all, nineteen entries were received and fifteen aeroplanes were presented to the judges at 10 a.m. on September 27th. The aeroplanes had to pass the eliminating test, which included a dismantling and housing test, as well as a dual control test, before 6 p.m. on September 28th, and the competition proper opened on September 29th.

It was at once evident that the time allowed to the engine manufacturers to develop the engines had been insufficient, and only eight out of the fifteen aeroplanes presented to the judges finally passed into the competition proper. A list of the entrants, together with their recorded performances, will be found in Table III.

Table II. also gives such details as I have been able to collect of the component weights of the types.

The results of the tests again exceeded expectations.

The maximum recorded speed was 79 m.p.h. (Beardmore) and the minimum recorded speed was 37.22 m.p.h. (Parnall). The Beardmore had a speed range of approximately 2/1, which is a notable performance for the weight/h.p. ratio (26.8) of the aeroplane.

The length of run to take off and the length of run to pull up were distinctly good, and compare favourably with similar figures for normal aircraft of half the weight/h.p. ratio.

Table IV. is a summary of the results of the tests carried out at Martlesham Heath as part of the competition for commercial aeroplanes in 1920. These figures call for little comment, and are reasonably comparable as the weather conditions were similar.

The general impression of pilots was that the performance and feel of the aeroplanes were satisfactory, but in all cases it was considered that more power was required to secure a better rate of climb.

This last competition, more than any other, demonstrated the safety of these light aeroplanes in a forced landing. Statistics for normal aircraft show that one forced landing in every four results in some damage to the aircraft. It has not been possible to give the number of forced landings which took place during the last trials, but in only one case was any damage done to the aeroplane. My own estimate of the number of forced landings is between forty and fifty. The facility with which the light aeroplanes could get into a field and get off from the same field again was quite remarkable.

TABLE II.

TRIALS AT LYMPNE, 1923 (SINGLE SEATERS).

Weight of Components as per cent. of Total All-up Weight.

Firm.	Aircraft.	Mono or Biplane.	Total Wings.	Total Tail.	Total Body.	Total Structure.	Total Power Unit.	Total Load Unit.
Air Nav. Co.	A.N.E.C. I. ...	M	30.0	2.7	14.3	47.0	21.9	31.1
A. V. Roe ...	Type 558 ...	B	19.1	3.1	18.6	40.8	24.4	34.8
A. V. Roe ...	Type 560 ...	M	19.7	3.0	18.7	41.4	22.9	35.7
De Haviland..	D.H. 53 ...	M	20.0	4.0	22.6	46.6	16.7	30.7
Gloucester ...	Gannet	B	16.8	2.5	23.3	42.6	17.4	40.0
Short Bros. ...	Gull	M	24.8	3.4	18.1	46.3	24.0	29.7
Handley Page	H.P.	M	29.8	4.0	17.1	50.9	11.1	37.3
R.A.E. Club..	Hurricane ...	M	21.0	3.6	14.9	39.5	27.5	33.0
Parnall ...	Pixie I. ...	M	14.0	3.5	17.3	34.8	27.1	38.1
Parnall ...	Pixie II. ...	M	14.6	3.5	17.2	35.3	26.9	37.8
Vickers ...	Viget	B	21.6	3.6	18.5	43.7	25.4	30.9
Eng. Elec. ...	Wren	M	24.7	4.8	19.6	49.1	12.5	38.4

TRIALS AT LYMPNE, 1924 (TWO-SEATERS).

Weight of Components as per cent. of Total All-up Weight.

Firm.	Aircraft.	Mono or Biplane.	Total Wings.	Total Tail.	Total Body.	Total Structure.	Total Power Unit.	Total Load Unit.
Bristol ...	Brownie ...	M	21.8	2.1	20.7	44.6	15.7	39.7
Cranwell ...	Cranwell ...	B	19.6	4.0	19.8	43.4	16.5	39.1
Beardmore ...	Wee Bee ...	M	20.9	2.4	21.3	44.6	15.9	39.5
Westland ...	Wood Pigeon ...	B	18.1	2.7	20.0	40.8	16.0	43.2
Westland ...	Widgeon ...	M	15.6	2.6	29.8	48.0	14.1	37.9
Air Nav. Co.	A.N.E.C. II. ...	M	20.6	2.9	17.5	41.0	18.2	40.8
Short Bros. ...	Satellite ...	M	21.7	3.4	26.2	51.3	13.4	35.3
Supermarine ..	Sparrow ...	B	23.1	3.1	14.6	40.8	19.9	39.3
A. V. Roe ...	Avis	B	19.2	2.4	27.1	48.7	14.4	36.9
Blackburn ...	Blue Bird ...	B						
Hawker ...	Cygnet I. ...	B	16.5	3.2	12.8	32.5	20.5	47.0
Hawker ...	Cygnet II. ...	B	16.8	3.3	13.1	33.2	18.6	48.2
Vickers ...	Vagabond ...	B	20.8	2.7	20.0	43.5	17.5	39.0
Parnall ...	Pixie III. ...	M	18.3	3.8	16.5	38.6	19.0	42.4
Parnall ...	Pixie III.a ...	B	23.8	3.5	15.4	42.7	17.8	39.5
Bristol ...	Bristol Fighter F.28	B	13.3	1.85	12.2	27.35	45.1	27.55

			Power Unit.		
Contractor.	Aircraft.	Type.	Engine.	H.P. at R.P.M.	Prop. Drive.
Bristol Aircraft Co.	Brownie I.	Cantilever Low Wing Monoplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Bristol Aircraft Co.	Brownie II.	Cantilever Low Wing Monoplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Cranwell Aero Club	Cranwell	Biplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
W. Beardmore and Co., Ltd.	Wee Bee	Braced High Wing Monoplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Westland Aircraft Works	Wood Pigeon	Biplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Westland Aircraft Works	Widgeon	Parasol Monoplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Air Navigation and Eng. Co.	A.N.E.C. II.	Braced High Wing Monoplane	1100 c.c. V-twin inverted Anzani	31 at 3000	Direct
Short Bros.	Satellite	Normal Cantilever Monoplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Supermarine Aviation Works	Sparrow	Biplane	1100 c.c. radial Blackburn	32 at 3000 27 at 2700	Direct
A. V. Roe and Co.	Avis	Biplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Geared 2 to
Blackburn Aeroplane and Motor Co.	Bluebird	Biplane	1100 c.c. radial Blackburn	32 at 3000 27 at 2700	Direct
Hawker Eng. Co.	Cygnet I.	Biplane	1100 c.c. Anzani	35 at 3600 31 at 3000	Direct
Hawker Eng. Co.	Cygnet II.	Biplane	1100 c.c. A.B.C. Scorpion	35 at 3600 31 at 3000	Direct
Vickers	Vagabond	Biplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Geared 2 to
Geo. Parnall and Co.	Pixie III.	Braced Low Wing Monoplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Geo. Parnall and Co.	Pixie III.a	Biplane	1100 c.c. Cherub	32.2 at 3200 25.5 at 2500	Direct
Geo. Parnall and Co.	Pixie III.a	Biplane	1100 c.c. radial Blackburn	32 at 3000 27 at 2700	Geared

TABLE III.

TRIALS AT LYMPNE, 1924 (TWO-SEATERS).

	Loading.				Aerodynamic Features.					
p. Drive.	Lbs Wt. Empty.	Lbs. Wt. Loaded.	Lbs./H.P.	Lbs./ sq. ft.	Length Overall.	Height on Ground.	Span.	Mean Chord.	Area sq. ft.	Aerofoil Section
Direct	500	862	26.8 33.9	4.23	26′ 3″	6′ 6″	30′ 7″	6′ 0″	204	Based on R.A.F. 15
Direct	500	873	27.2 34.3	4.55	26′ 3″	6′ 6″	34′ 7″	6′ 0″	192	Based on R.A.F. 15
Direct	515	980	30.5 38.5	3.78	23′ 6″	7′ 8″	29′ 8″T 22′ 8″B	5′ 0″T 4′ 0″B	259	No. 64
Direct	402	837	26.0 32.8	4.01	22′ 2″	5′ 6″	38′ 0″	5′ 0″	208.5	Shackleton .0732 cambe
Direct	440	780	24.2 30.6	3.88	19′ 6″	7′ 0″	22′ 9″ 22′ 9″	3′ 8″ 3′ 8″	201.5	No. 64
Direct	475	896	27.8 35.1	4.81	21′ 0″	6′ 11″	30′ 8″	4′ 9″	180.4	Airscrew No. R. & M. 32
Direct	460	830	26.8	3.95	20′ 8″	6′ 8″	38′ 0″	5′ 0″	210	Shackleton .0732 cambe
Direct	640	1014	31.5 39.8	4.82	23′ 9″	5′ 6″	34′ 0″	5′ 6″	211	R.A.F. 15 t Glenmartin
Direct	531	905	28.3 33.5	2.87	23′ 0″	7′ 3″	33′ 6″T 27′ 6″B	5′ 8″T 3′ 6″B	316	Sloane (top) A.D.I. (botto
ed 2 to 1	550	920	28.6 36.1	2.79	24′ 0″	9′ 0″	30′ 0″T 30′ 0″B	4′ 6″T 4′ 6″B	330	64
Direct	500	875	27.3 32.4	3.07	21′ 8″	7′ 10½″	28′ 0″T 28′ 0″B	4′ 9″T 4′ 9″B	284.6	
Direct	380	750	21.4 24.2	3.52	20′ 5″	6′ 6″	28′ 0″T 23′ 0″B	4′ 3″T 2′ 6″B	213.2	M/80 Loenin
Direct	385	755	21.6 24.4	3.55	20′ 5″	6′ 6″	28′ 0″T 23′ 0″B	4′ 3″T 2′ 6″B	213.2	M/ Loenin
ed 2 to 1	428	887	27.6 34.8	3.15	22′ 0″	7′ 10″	28′ 0″B 28′ 0″T	4′ 6″B 4′ 6″T	282	F. 15
Direct	463	831	25.8 32.6	5.15	21′ 3″	6′ 0″	32′ 5″	2′ 11½″	161.5	R. M. 32 Airscrew 1-
Direct	523	891	27.7 35.0	3.4	21′ 3″	6′ 3″	25′ 8″T 32′ 5″B	2′ 11½″	262.5	R. & M. 32 Airscrew 1- bottom 8
Geared	552	920	28.7 34.1	3.5	21′ 3″	6′ 3″	25′ 8″T 32′ 5″B	2′ 11½″	262.5	Top plane unknown

		Performance.						Reliability.	
[redacted]rofoil Section.	Aspect Ratio.	High Speed for ten laps M.P.H.	High Speed for one lap M.P.H.	Low Speed M.P.H.	Speed Range M.P.H.	"Take Off" over 25ft. Yards.	Landing Run over 61ft. Barrier. Yards	Hours Flown.	Miles Flown.
Based on R.A.F. 15	6.0	65.19	— 66.02	38.73	26.46 27.29	215	102.6	10.375	512.5
Based on R.A.F. 15	6.0	—	—	—	—	—	—	—	—
[redacted] No. 64	5.36	—	—	—	—	—	99.4	17.889	762.5
Shackleton 9732 camber	7.6	70.11	— 79.37	39.66	30.45 39.71	235	124	11.912	737.5
[redacted] No. 64	6.15	—	— 58.96	—	—	—	—	2.528	125
[redacted]screw No. 4, R. & M. 322	6.46	—	—	—	—	—	—	—	—
Shackleton 9732 camber	7.6	—	—	—	—	—	—	—	—
[redacted].A.F. 15 to [redacted]lemartin 4	6.2	—	—	—	—	—	—	—	—
[redacted]loane (top), [redacted]D.I. (bottom)	7.4	—	—	—	—	—	—	—	—
[redacted] 64	6.7	—	—	—	—	—	—	—	—
[redacted]	—	—	—	—	—	—	—	—	—
[redacted]/80 Loening	5.15	—	— 71.23	43.95	— 27.28	269	66.7	8.382	400
[redacted]/[redacted]Loening	5.15	—	— 71.31	37.42	— 33.89	250	72.66	10.4123	475.0
[redacted]F. 15	6.22	—	—	—	—	—	—	—	—
[redacted].M. 322, [redacted]irscrew 1-4	7.0	—	—	—	—	—	—	—	—
& M. 322, Airscrew 1-4 bottom 8	7.0 7.3	—	—	—	—	—	—	—	—
Top plane unknown	7.0 7.3	—	— 59.84	37.22	— 22.62	301	70	10.764	450

TABLE IV.

AIR MINISTRY COMMERCIAL AIR TRIALS.

MARTLESHAM, 1920

	Firm.	Aircraft.	Engine H.P.	Getting Off. Yards Run.	Height in ft.	Landing. Height in ft.	Yards Run.
Large Aeroplanes.	Handley Page	W.8	2 × 450	275	74·1	50	203
	Vickers ...	Vimy Commercial	2 × 350	275	20.45	50	308
	Central Aircr. Co. ...	Centaur ...	2 × 100	275	0	50	281
Small Aeroplanes.	Austin Motor Co. ...	Kestrel ...	100	175	13.18	50	244
	Bristol Aero. Co. ...	230 Siddeley "Puma" ...	230	175	10.27	50	313.5
	Westlands ...	Six-Seater ...	450	175	22.75	50	235
	A. V. Roe ...	Triplane ...	230	175	1.18	50	230.1
	Sopwith Aviation ...	Antelope ...	200	175	23.0	50	187.7

Turning to the structural design of the aircraft, the general remarks made earlier in this paper on the structure of the 1923 light aeroplanes apply equally to the aeroplanes of 1924 with some notable exceptions. The undercarriages fitted to most aeroplanes were distinctly superior to those fitted on the single-seater types. The get-off and landing tests, I do not doubt, were responsible for this. The "Satalite" and "Avis" are fitted with a form of Oleo undercarriage and the results obtained from these were entirely satisfactory. The Westland was fitted with an undercarriage with a steel spring return and a ferrodo lined tube to absorb energy. The Bristol Co. entered one aeroplane with a complete all-metal structure. The production of an aeroplane of this size in metal is a distinct achievement, and it is of interest to note that this aeroplane won the second Air Ministry as well as the Duke of Sutherland's prize. How far it will be possible to produce such a structure on a commercial basis is a matter of conjecture. My own personal view is that it would be a matter of extreme difficulty to produce such an aeroplane at a reasonable price.

It is of interest to note that nine biplanes were presented to the judges as against six monoplanes, showing that designers in this country as a whole consider that for all-round suitability—that is, for performance and robustness in handling—the biplane is the superior type.

It is difficult from the results of the competition to sort out the relative aerodynamic efficiencies and performances of the two types. Monoplanes won the principal prizes. The reliability prize and the second prize for taking off and landing were won by biplanes, so that so far as actual prizes were concerned the monoplanes were easily first. The actual results, however, were so much affected by engine difficulties that the above comparison is of very little technical value and is distinctly unfair to the biplane. Many of the aeroplanes were unable to finish the ten laps of the speed test, and for that reason were awarded no marks for speed range. All of them, however, were able to finish one lap of the high-speed course (the figures are given in Table III.), and if this measurment is taken as a basis of working, there is a considerable difference in the relative positions. The Beardmore monoplane is still first. Immediately behind is the Hawker biplane (A.B.C.). The third is

the Bristol monoplane, and following that the Hawker biplane (Anzani), followed again by the Parnall biplane. Even these, however, are not entirely rid of engine trouble, as it is known that some of these aeroplanes could have done better in their relative performances if the engines had not given trouble. It does indicate, however, that for the purposes of the competition there is little to choose between the best monoplane and the best biplane, with the balance in favour of the monoplane.

The tests were carried out in very fortunate weather. The taking off, landing and slow-speed tests were carried out in weather conditions which amounted to a flat calm for all practical purposes.

I attach a table (Table V.) showing the wind readings taken during the week in the middle of the aerodrome about 8ft. from the ground, and better conditions than these are rarely found in this country.

TABLE V.

SUMMARY OF AIR METER READINGS TAKEN AT LYMPNE AERODROME DURING THE LIGHT AEROPLANE TRIALS, 29-9-24—4-10-24.

Date.	Time of Observation.	Direction.	Speed. m.p.h.
29-9-24	10.00	S.	10.4
,,	10.03	S.	15.4
1-10-24	09.30	S.E.	4.6
,,	09.35	S.E.	5.8
,,	11.21	S.E.	9.3
,,	11.24	S.E.	8.3
,,	11.50	S.S.E.	9.3
,,	11.53	S.E.	8.9
,,	12.13	S.S.W.	9.2
,,	12.15	S.W.	9.3
,,	14.59	S.	8.8
,,	15.02	S.W.	9.4
,,	10.01	S.S.W.	7.3
,,	10.03	S.	9.6
,,	10.37	S.	9.4
,,	16.41	S.W.	5.6
,,	17.34	S.W.	4.4
,,	17.40	S.W.	4.6
2-10-24	09.15	N.W.	1.5
,,	09.18	N.W.	3.1
,,	10.07	W.N.W.	5.3
,,	10.10	W.N.	5.3
,,	10.44	W.N.W.	2.9
,,	10.48	W.	1.6
,,	11.43	S.S.W.	4.0
,,	11.47	S.W.S.	3.3
,,	12.30	S.E.	4.3
,,	12.33	S.E.	5.2
,,	13.15	S.S.E.	4.6
,,	13.18	S.E.S.	5.2
,,	10.43	W.N.	3.6
,,	16.47	W.N.W.	4.1

TABLE V. (*continued*).

Date	Time of Observation.	Direction.	Speed. m.p.h.
3-10-24	08.48	E.	5.1
,,	08.52	E.S.E.	3.4
,,	09.48	S.S.E.	8.5
,,	09.51	S.E.	8.2
,,	11.10	S.S.E.	6.8
,,	11.13	S.S.E.	6.8
,,	11.49	S.S.E.	7.1
,,	11.52	S.S.E.	7.2
,,	12.31	S.E.	9.8
,,	12.34	S.E.	9.2
,,	13.45	S.E.	7.0
,,	13.48	S.E.	5.8
,,	14.41	S.E.S.	7.5
,,	14.44	S.E.	7.2
,,	15.55	S.E.	4.0
,,	15.58	S.E.	5.0
,,	17.30	E.	2.0
,,	17.33	E.	2.0
4-10-24	09.02	E.S.E.	5.0
,,	09.05	S.E.	5.3
,,	09.57	S.S.E.	7.3
,,	10.00	S.E.S.	6.2
,,	10.31	S.E.S.	3.9
,,	10.34	S.E.	4.7
,,	10.55	S.S.E.	4.3
,,	10.58	S.	4.9
,,	11.10	S.E.	4.0
,,	11.13	S.	3.7

The competition was of considerable interest from an engine standpoint. As a result, it is possible to make a fair estimate of the power required for aircraft of this type. During the week a large number of engine failures were reported and a general impression was that engines were unsatisfactory, whereas closer investigation shows that they were, in fact, doing well under the circumstances and that many of the troubles experienced were due to overloading. From the type tests of the "Cherub" engine, the normal power should be 25.5 h.p. at 2,500 revs., and the "Blackburn" 27 h.p. at 2,700 r.p.m. In every case these speeds were exceeded, and the aeroplanes were flown in most cases with the engines giving more than the maximum permissible r.p.m. Under these conditions it is not astonishing that a large number of failures were experienced.

I think it is clear from the results of the competition that more power is required and that engine speeds should be kept down if reliability is to be attained.

Once again the geared type of engine failed to keep in the air, and although the aerodynamic advantage of the geared type is certain, it would appear that considerations of engine design preclude its use. That is most regrettable, as it puts an important limit to engine speed and has the effect of increasing engine size still further.

Conclusions

Having put on record the facts as they have been ascertained by this series of competitions, it is of considerable interest to review the position now, with a view to considering what steps are desirable for the future development of this type of aircraft.

The main object of these competitions was to make flying cheap and safe, and thus to popularise it to the extent of making it part of our national life.

You will observe that a start was made from the beginning with the glider and progressive tests have been carried out with the single-seater light aeroplane and the two-seater dual control type. From these experiments we have learned the h.p. necessary to give a reasonable performance for each of these types. In the case of the single-seater it is apparent that 15-18 h.p. is adequate for reasonable performance. In the case of the two-seater, it is clear that somewhere near 40 h.p. is required. Hitherto the aircraft designer has been dependent entirely on the engine designer, and aircraft design has progressed more by virtue of increased power than by increased aerodynamic efficiency. In the light aeroplane this position is being reversed, and the aircraft designer has now put forward his best efforts in order to obtain a maximum aerodynamic efficiency with a minimum structure weight, consistent with strength and robustness, if the light aeroplane is ever to become a factor in aviation.

A glance at the table of weight schedules both for 1923 and 1924 shows that the structure weights of these aeroplanes are relatively high. The average figure appears to be 44 per cent. for the single-seaters and 42 per cent. for the two-seaters, as compared with a corresponding figure of about 32 per cent. to 33 per cent. for larger types of aircraft, with the same factor of safety. The figures for a Bristol Fighter are attached at the end of the table to give an approximate comparison.

It will be noticed also that the average load carried amounts to 37 per cent. in the case of the single-seaters and 41 per cent. in the case of the two-seaters of the total as against a figure of 25 per cent. to 30 per cent. for normal aircraft. Some of this difference is accounted for by the small amount of petrol carried by the light aeroplane. A further notable feature is the low value of the power unit weight. That again is affected by the quantity of petrol which is included in this item. It would appear, however, that there is some margin for improvement in the structure weight by the adoption of new methods of construction and new materials. Hitherto these aeroplanes have been designed on established methods and with standardised materials, and it is possible that a reconsideration of these factors would lead to improvement. The figures for the Hawker aeroplanes indicate what can be done by painstaking design and close attention to details.

It is also clear that the aeroplanes as tested at these competitions were not cheap to build, but on the other hand no effort has been made to manufacture them, because there is no market in which to sell them. Unless both first costs and running costs are kept down, the market will be a restricted one.

The matter of petrol consumption must not be lost sight of. In the 1923 competition a consumption of 87 miles per gallon was attained. In the 1924 competition, so far as I can ascertain, the average consumption was of the order of 30 miles per gallon, and it is important that we do not, in our desire to provide plenty of power, increase this petrol consumption until it becomes, once again, an important factor in the operation of these light aeroplanes.

Although a great deal of work has been done during the past three years towards the solution of the problem of supplying the cheap and safe aeroplane, a great deal more has to be done, and every care should be exercised that in correcting the defects which have been discovered by these competitions we do not sacrifice the important assets which the aeroplanes already possess.

It will be seen that in all these tests and discussions the question of a small seaplane has not been considered. I would suggest that there is ample scope for such development in this country, where suitable waters are numerous and where a considerable proportion of the youth of the country are interested in matters concerning the sea. A step up in engine size is inevitable for the small

seaplane, but I believe that a suitable aircraft could be made with an 1100 cc engine.

I wish to apologise for my very rough analysis of the data. Owing to the short time available the paper had to be written whilst the data was being collected, and there was not time to make a close survey of the figures.

APPENDIX I.

Motor Glider Competition at Lympne Aerodrome, 8th-13th October, 1923

Organisation

The Competitions will be conducted by the Royal Aero Club.

Motor Glider

The Competitions are open to any heavier-than-air machine with engine, the total piston displacement of which does not exceed 750 cc. The Royal Aero Club reserves to itself the right to check the piston displacement of any engine taking part in the Competitions. Any additional motive power produced by the personal exertions of the occupants during flight is allowed. The machine must not be supported either wholly or in part by any gas which is lighter than air.

Competitors may use any launching device provided by themselves.

Pilot

The weight of the pilot must be made up to a minimum of 168 lbs.

All pilots must be weighed prior to the start of the Competitions. Pilots under the minimum of 168 lbs. must carry the additional weight necessary to make them up to this weight, and this will be checked before and after each flight.

Transport

Competitors must demonstrate to the Officials that the machine is capable of being transported on the ground a distance of one mile by not more than two persons without the use of any extraneous tackle within a period not exceeding three hours. The selected course for this test will include the getting out of a field through an ordinary gateway, 10ft. wide, and proceeding along a 15ft. road, occupying not more than half the width of the road.

Machines may be presented to the Officials for the Transport Test from 10 a.m. on Saturday, 6th October, 1923.

Machines must be presented to the Officials fully erected.

Any time occupied in dismantling will be included in the three hours allowed for the Transport Test.

There is no restriction as to the number of persons engaged in any dismantling necessary for the Transport Test, but only two persons will be allowed for the purposes of Transport.

No special devices will be allowed for the Transport Test unless carried as part of the equipment of the machine in flight during the Competitions.

This test must be passed before any flight is made in any Competition.

Course

All flights will be made over a triangular course of approximately 12½ miles, the exact location of which will be announced later.

The Turning Points will be marked by White Crosses on the ground, which each Competitor must pass on his left at a height of not more than 1,000ft., and at a sufficiently close range so that his number may be easily identified by the Official Observers.

The "Daily Mail" £1,000 Prize

To be awarded to the Entrant of the machine which accomplishes the longest distance in one flight with one gallon of fuel, providing such flight is not less than fifty miles.

This Prize is open to all nationalities.

Fuel

The distance covered by the use of one gallon of fuel only will be reckoned. Competitors, however, will be required to finish each flight at Lympne Aerodrome by crossing the finishing line in flight. No flight will count if the landing occurs outside the Aerodrome.

In order to enable this to be done, Competitors will be served out with a measured quantity in excess of the one gallon as required by them. After the flight the amount remaining in the tank will be measured and the distance flown on the one gallon will be calculated *pro rata*, provided more than one gallon is consumed.

Competitors who consume less than one gallon will be treated as if they had consumed the whole of one gallon.

The Sutherland £500 Prize

To be awarded to the Entrant of the machine which accomplishes the longest distance in one flight with one gallon of fuel, providing such flight is not less than fifty miles.

The Entrant and Pilot must be British subjects, and the machine and engine must have been entirely constructed in the British Empire.

Fuel

The distance covered by the use of one gallon of fuel only will be reckoned. Competitors, however, will be required to finish each flight at Lympne Aerodrome by crossing the finishing line in flight. No flight will count if the landing occurs outside the Aerodrome.

In order to enable this to be done, Competitors will be served out with a measured quantity in excess of the one gallon as required by them. After the flight, the amount remaining in the tank will be measured and the distance flown on the one gallon will be calculated *pro rata*, provided more than one gallon is consumed.

Competitors who consume less than one gallon will be treated as if they had consumed the whole of one gallon.

The Abdulla £500 Prize

To be awarded to the Entrant of the machine which covers two circuits of the course (approximately 25 miles) in the fastest time.

This Prize is open to all nationalities.

The fuel allowance is not limited.

The starting and finishing line must be crossed in flight.

The Society of Motor Manufacturers and Traders £150 Prize, and the British Cycle and Motor Cycle Manufacturers' and Traders' Union £150 Prize

To be awarded to the Entrant of the machine which flies the largest number of completed circuits of the course during the period of the Competitions, with a minimum of 400 miles. Circuits flown in the other Competitions will count towards these Prizes.

The Entrant and Pilot must be British subjects, and the machine and engine must have been entirely constructed in the British Empire.

The same machine and engine must be used throughout, and parts will be marked to ensure this, but special tanks will be permitted, the fuel allowance not being limited.

APPENDIX II.

Two-Seater Light Aeroplane Competitions, 1924

(Under the Competition Rules of the Royal Aero Club)

Prizes

£3,000, presented by THE AIR COUNCIL.
£500, presented by THE DUKE OF SUTHERLAND.
£150, presented by THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS.
£150, presented by THE BRITISH CYCLE AND MOTOR CYCLE MANUFACTURERS' AND TRADERS' UNION.
£100, presented by CAPTAIN C. B. WILSON, M.C.

Organisation

The Competition will be conducted by the Royal Aero Club, under the Competition Rules of the Royal Aero Club.

Light Aeroplane

The Competition is open to any aeroplane, the total piston displacement of the power plant of which does not exceed 1100 cc.

Two-Seater, Dual Control

The aeroplane must be a two-seater fitted with dual control, and an air-speed indicator must be visible from either seat.

British Manufacture

The aeroplane, including the engine and magneto, must have been designed and constructed in the British Empire.

Fuel

The ingredients of the fuels used must be commercially obtainable in bulk.

Competitors

The Entrant and Pilot must be British subjects.

Load to be Carried

The load to be carried, exclusive of fuel, must be made up to 340 lbs. This includes the weight of the pilot and passenger (if carried). If there is no passenger, the balance of the total weight required must be carried in the spare seat.

The carrying of a passenger is optional, except in the Eliminating Test "B," Demonstration of Dual Control, in which case it is not permitted.

Eliminating Tests

The Eliminating Tests will be as follows:—

(A) *Dismantling, Housing and Re-erecting.*—For this test the aeroplane must be presented to the Official fully erected.

It must then be dismantled or folded in such a manner as to permit of its being completely transported in one journey, without the use of any extraneous tackle, over a distance of not more than 25 yards, and placed in a shed 10ft. in width. It must then be taken outside the shed and re-erected.

Two persons only will be allowed to handle the aeroplane throughout this test, and the time occupied must not exceed two hours.

No special devices will be allowed unless carried as part of the equipment of the aeroplane in flight during the Competitions.

(B) *Demonstration of Dual Control.*—This test will consist of two separate flights, each of one complete lap of the course, at the termination of each of which one figure of eight must be flown within the boundary of the Aerodrome.

The pilot must be alone and occupy alternately the two seats in the aeroplane.

Eliminating Tests "A" and "B" must be carried out in this order, and must be passed to the satisfaction of the Officials before any flights are made in the Competition proper.

Aeroplanes must be presented to the Officials, fully erected, for the Eliminating Tests at 10 a.m. on Saturday, 27th September, 1924. Aeroplanes not so presented will be debarred from taking part in the Competitions.

The Eliminating Tests will commence at 10 a.m. on Saturday, 27th September, 1924, and will be continued on the following day. These tests must be completed by 6 p.m. on 28th September. Aeroplanes not having done so will be debarred from taking part in the Competitions.

Competition.

In order to be eligible for any of the Prizes offered, Competitors must complete at least ten hours' flying in the various tests during the period of the Competitions.

Prizes

1st Prize, £2,000, presented by the Air Council.

2nd Prize, £1,000, presented by the Air Council.

The Prize of £2,000 will be awarded to the entrant of the aeroplane which shall have obtained the greatest aggregate of marks in the Schedule of Tests.

The Prize of £1,000 will be awarded to the entrant of the aeroplane which is placed second.

Schedule of Tests

1. *Range of Speed.*
   (*a*) High Speed. (*b*) Low Speed.
2. *Getting Off.*
3. *Pulling Up.*

High Speed

This test will be carried out over a course, in two separate flights of approximately 75 miles each.

An interval will be allowed between the two flights for taking in fuel and oil only.

All flights will be made over a triangular course of approximately 12½ miles.

The Turning Points will be marked by White Crosses on the ground, which each Competitor must pass on his left at a height of not more than 500ft., and at a sufficiently close range so that his number may be easily identified by the Official Observers.

The same line will be used for starting and finishing. Competitors will be at liberty to take off from any point on the Aerodrome, but will be timed from the first time they cross the starting line in flight, keeping the Aerodrome Turning Point on their left.

There is no restriction as to the number of attempts allowed in the High Speed Test provided such flights do not interfere with the carrying out of the other tests.

Competitors must hand in written notice to the Official Office at least half an hour before each flight is made. Competitors not starting within fifteen minutes of the time stated in the notice may be required to put in a further notice.

Low Speed

The aeroplane will be timed up and down a straight course of not less than 500 yards.

The width of the course for the Low Speed Test will be 25 yards, and will be indicated by red flags placed at intervals on each side. The aeroplane will be considered as being on the course provided any part remains within the boundaries indicated by the red flags. No marks will be awarded if the aeroplane flies outside the limits of the course.

The course must be covered twice in each direction in one flight, at a constant height of not more than 20ft. The speed of each of the four flights will be taken and the average of the four speeds will constitute the performance.

Competitors will be at liberty to take off from any point on the Aerodrome. They must enter the Low Speed Course within five minutes of their starting time. On completing the course after each of the first three flights the Competitors must turn and immediately re-enter the course. On completing the test the Competitors must land, so as not to interfere with other tests. The Stewards will be the sole judges as to whether time has been unnecessarily wasted between the flights on the course, and may rule that no marks be awarded.

Range of Speed

No marks will be awarded unless the aeroplane satisfies both the following conditions :—

High Speed	... ...	Not less than 60 m.p.h.
Low Speed	... ...	Not more than 45 m.p.h.

Marks will be awarded for Range of Speed expressed as a percentage of the Low Speed, *e.g.* :—

High Speed is	... ...	60 m.p.h.
Low Speed is	... ...	40 m.p.h.
Range of Speed is	... ...	20 m.p.h.

Percentage, Range of Speed / Low Speed = 50 per cent.

The basis of marking to be :—

No marks for a percentage of $33\frac{1}{3}$ per cent. or less.

Eight marks for every 1 per cent. over $33\frac{1}{3}$ per cent., and parts of 1 per cent. *pro rata*.

Getting Off

This test will consist of a take off, starting from rest and flying in a straight line over a barrier 25ft. high.

The pilot will select his own distance from the barrier.

Marks will be awarded according to the distance from the starting point to the barrier, on the following basis :—

One mark for every yard by which the distance is less than 450 yards.

The wheels of the aeroplane will be placed on the line of start selected by the Competitor. The start will be a standing one. No assistance, launching devices or chocks will be permitted for the actual getting off.

Competitors must land immediately after the attempt.

Pulling Up

This test will consist of a straight landing over a barrier 6ft. high.

Marks will be awarded according to the distance from the barrier at which the aeroplane comes to rest, on the following basis :—

One mark for every yard by which the distance from the centre of the barrier is less than 150 yards.

The engine may be shut off before crossing the barrier.

Any form of braking device may be used provided it is carried throughout the Competitions.

The distance will be measured from the centre of the barrier in a straight line to the furthest point of contact of the aeroplane with the ground. Only normal straight landings will be measured. In the event of damage to the aeroplane which in the opinion of the Stewards would prevent further flight, no marks will be awarded.

Low Speed, Getting Off, and Pulling Up Tests

The Stewards will decide from day to day the time allotted for the above tests. Their decision will be announced on the Official Notice Board at 9.30 a.m. each day, together with the order and time of starting.

All Competitors will be allowed the same number of attempts, but any Competitor failing to start within five minutes of his starting time will not be allowed to start, and the attempt will count against him.

The Stewards may allow additional attempts in the same order, as time permits.

Discussion

Major Low remarked that he dissented entirely from the view that size had nothing to do with performance. There was a quite satisfactory theory of structural dimensions which indicated just such tendencies as the lecturer had pointed out in light aeroplanes. One need only glance at the stuffed vulture suspended over the Chairman's head and compare it with a swift at one end and an ostrich at the other end of the scale to see that Nature had arrived at similar conclusions after a hundred thousand years of experiment.

The details of the subject were too numerous to go into then.

(*Added in writing after the meeting.*)

With reference to General Brancker's query, whether a new type could be developed on a small scale and the results applied on a large scale, the answer was undoubtedly that this could be done. There were two kinds of similarity, structural and aerodynamical, the former concerned with the internal structure, the latter only with the surface exposed to the wind. In both cases there were difficulties of detail all of which required experience and sound judgment on the part of the designer and some of which had not yet been got over. Many important points had been made by other speakers and he need not carry the discussion further.

In conclusion, he did not think it had been yet pointed out that the weight of the pilot became relatively the controlling factor at the light end of the scale.

Were he in practice as a designer he would certainly try to get a bantam pilot and build down to his weight unless the regulations prevented him.

Major Mayo congratulated Major Buchanan on his very excellent survey of these competitions and of the development of the light aeroplane from its inception. He had analysed the results in such a way as to show clearly what had been done at these competitions.

There were, however, one or two small points in the paper to which he would like to draw attention. Taking the question of loading per h.p., Major Buchanan had told them that the 1923 machines worked up to a power loading of 60lbs. and that most of the machines achieved 30-35lbs., and had gone on to say that this was impossible with bigger machines. He ventured to say that that was not so, but that an equally efficient machine on a larger scale could be made. It was very important that no claim should be made for the small machine that could not be substantiated. Major Buchanan gave the efficiency of the Gull machine as 14 to 1 as compared with 5 to 1 and 8 to 1 for military and civil types. He ventured to think it was simply a question of what the machine was intended to do. If a machine had to be built with a large number of external obstructions and at the same time had to satisfy severe conditions in regard to maximum speed and load-carrying capacity, its efficiency naturally went down. If, on the other hand, a larger machine were built on the same lines as the small ones he thought the same standard of efficiency could be reached.

Major Buchanan had told them that the actual stalling speeds at Lympne were considerably lower than the recorded low speeds. He, however, ventured to say that the stalling speeds were in fact practically the same as the actual recorded low speeds. He thought this was proved by the fact that when carrying out the low speed tests most of the machines actually touched the ground during several of the attempts. If by stalling speed was meant the critical angle of the wings then it might be lower, but the speed at which control was lost was very little lower than the recorded low speeds.

He wished to make one or two remarks on the general question of policy with regard to light aeroplanes. Up to the present we had failed to define what it was we wanted to achieve. Major Buchanan had pointed out the very impor-

tant point that after the petrol consumption had been reduced below a certain limit it became of relatively small importance. He would suggest that we had already gone below that figure. The petrol cost in operating the machines this year was already not more than a third of the cost of depreciation. That was taking very generous figures indeed as to the life of the machines and cost of repairs and upkeep. It seemed to him that petrol consumption was not the prime consideration. They wanted a machine that was cheap to construct and efficient for the purpose for which it was required. If it was for school work the great essentials were that it should be robust, that the landing gear should not be easily damaged and should have good shock absorbing qualities, and that the machine should not be liable to damage by handling. In order to make such a machine a considerable increase in the available h.p. would be required. He sincerely hoped that before a final decision was taken as to further action at the Air Ministry it would be realised that a big step must be made in this direction, and he did not fear that this would result in an increase of petrol consumption of sufficient importance to matter. The figure in a good many people's minds was a cubic capacity of two litres and that would give a h.p. which to his mind was not unduly on the high side. If there was going to be another competition next year the conditions should be laid down as soon as possible. The requirements should be stated more definitely. For instance, if the machines were required for training purposes it should be very clearly set out what were the requirements for a school machine; for example, whether the pupil and instructor should sit close together, the requirements as to visibility, etc., so that designers would know what they had to do. It seemed to him that another competition next year on the same lines as this, but with a larger engine, would not meet the case, because there would not be time to develop an engine with 2,000 c.c. He suggested that there should be an engine competition next year and the successful engine should be selected as a standard to be used by all competitors in an aeroplane competition to be held in the following year.

He thought very good use could be made of this year's size of engine for a single-seater machine. He suggested that a single-seater machine designed for an 1,100 c.c. engine would make an excellent machine for use by the service for cross-country practice and general flying, enabling a very considerable economy in fuel to be effected.

Mr. W. O. MANNING thought they were very greatly indebted to Major Buchanan for the trouble which he had taken in placing the results of the last three years' competitions in a form not previously available. One point he wished to refer to was structure weight. He would suggest that structure weight was not the important criterion in aircraft but that the important figure was the weight empty, because the significant figure was the percentage weight of useful load to total weight of machine.

With regard to engine power, this question was wrapped up in that of what performance was desirable, what top speed, climb, etc. The larger the engine the higher became the cost of upkeep. In the Beardmore Wee Bee with the Bristol Cherub engine, two men could remove the engine and replace it in half an hour. With a 70-80 h.p. engine a small crane would be necessary, which would increase the cost of upkeep considerably. He thought there was a connection between engine reliability and good design. The better the design of the machine the less heavy was the work required from the engine.

He thought Major Buchanan was somewhat pessimistic about the petrol consumptions attained this year. He would suggest that at the average speeds flown the petrol consumption could not be considered high. He did not think that any kind of light car could approach that figure. No vehicle known to man could travel so far on a gallon of petrol at the speeds attained.

With regard to the future of light aeroplanes, he thought there was a good

deal to be said for racing. The present racing machines, such as those used for the Pulitzer Trophy, were much too expensive and he would suggest that by limiting engine power sufficiently the design and construction of a racing machine would become financially possible for most aircraft forms; 750 c.c. engined aeroplanes would be much cheaper to run and would be equally interesting aerodynamically. The fastest machine would obviously be the most aerodynamically efficient one. One could expect the same effects from light aeroplane racing as from light car racing.

Air Vice-Marshal Sir W. S. BRANCKER said he was speaking from the user's point of view; he was interested in the development of the light aeroplane in three ways: Its relation to air transport; the proposed creation of light aeroplane clubs; and air racing. He would like to ask the technical experts two questions concerning air transport: first, how far can a small machine be used for testing out new designs and new features in design before constructing a really big machine? And secondly, if this was possible, why could not a big machine be made with as great a disposable load per horse-power as had been obtained by several small ones in the competition? The lecturer had indicated that some of these machines had carried 15lbs. per horse-power of disposable load at 75 m.p.h. A big machine which could do this would be of very great value to air transport.

With regard to light aeroplane clubs, he was very well satisfied with the result of the competition. A number of excellent aeroplanes had been produced, but the Air Ministry would not be in a position to recommend the purchase of any of these types by light aeroplane clubs, until the engine situation was more satisfactory. This was being pressed on as fast as possible. There were two questions he would like to ask which concerned light aeroplane clubs: First, to what speeds can engines be pushed without incurring serious difficulties and expenses in maintenance? He understood one designer had recommended boosting an 1,100 c.c. engine up to 4,000 revs. Could the ordinary mechanic of a light aeroplane club be expected to look after such an engine properly? Secondly, he had heard certain of the designers say that most of the machines at Lympne were too light to be cheap. With only 1,100 c.c. it was necessary to cut all the limits very fine, which resulted in the expensive machine. Would it be better to go a little larger, both in the engine and in the machine, in order to obtain cheaper production?

As regards air racing, the Committee of the Royal Aero Club was very much alive to the possibilities of light aeroplane races, and he hoped that they would be a prominent feature in next year's programme.

He could not say at the moment what the future policy of the Air Ministry would be, but they were thinking hard already and were trying to formulate a scheme by which the machines already in existence would be employed and further development and improvement assured.

Captain W. H. SAYERS said that the point in Major Buchanan's paper that interested him very considerably was that of structure weight for each aeroplane. Structure weights in the form which he fancied Major Buchanan had adopted in this case were apt to be rather misleading, and if the figures included pilots' seats, control, etc., he would like to point out that these items in a light aeroplane weighed nearly as much as in a big machine. Therefore it was not surprising that on the whole the structure weights appeared to run rather high. It was quite possible to get structure weights very low in small machines. In the "Kitten," at Grain, they were reproved for estimating for a structure weight of only 25 per cent. with a total loaded weight of 550lbs. The "Kitten" was accordingly stressed at 650lbs., but it came out at 490lbs. But such an aeroplane was extremely expensive to build—as expensive as a standard fighting machine—and a light aeroplane to serve its purpose had to be cheap and easy to maintain.

Another point he wished to speak about was the comparison of monoplanes with biplanes. It was quite true that building a biplane and cutting things fine one could get nearly the same performance as in a monoplane, but it would cost two or three times as much as a monoplane as it was a much more complicated structure.

He entirely disagreed that more powerful engines were needed. What was wanted was an engine that would develop the same power regularly. The performance of these light aeroplanes was practically that of the standard training machine used in the R.A.F. to-day. In fact he would doubt if any aeroplane of that in the Service gave anything better than the performance of the Beardmore "Wee Bee." It would perhaps get over a 20ft. obstacle with a less run, but that was merely due to the heavy loading. If one could get with 30 h.p. a performance equal to that of the standard training machine, and if that machine could land in places in which the standard machines certainly could not, he thought that it could not be said that more power was necessary.

He quite agreed that a slightly larger engine was wanted for greater reliability, but that putting up the engine power was a move entirely in the wrong direction. He thought the small capacity heavily pressed engine had the obvious disadvantage of requiring careful maintenance if it was to give the necessary power—a larger capacity slower running engine giving the same power should be more reliable and probably cheaper in every way, particularly in maintenance.

He thought there was more to be said in favour of a petrol consumption limitation than had yet been said. After all you could only get 2 h.p. hours per lb. of petrol and by limiting consumption you could in fact limit power without the drawbacks of the cylinder capacity rating. Whatever cylinder capacity rating was adopted for competitions, it would always lead to pressing the engine to its limit of power and the resulting loss of reliability. If power were limited by a limit of petrol consumption there would be a much less incentive to overpressing the engine.

Flight-Lieutenant R. A. de H. HAIG pointed out that a drawback of a low-winged monoplane was that should the machine turn over when landing it was dangerous for the pilot. He had turned over several times in biplanes and been able to get out without too much difficulty.

On the subject of the geared engine, he thought it was rather unfair to judge it entirely from the competition results as it had only been on the stocks for a couple of months before the meeting.

Sir HENRY WHITE-SMITH thought it was perhaps unwise to arrive at conclusions as to altering the power to be used in next year's competition without considering whether it would not be better to repeat the competition already held. There must be developments to be obtained both by the aircraft designer in his structure and also by the engine designer, yet by changing the conditions the possible developments in these two directions would be thrown away. It seemed undesirable to go away from the present type of light aeroplane before its possibilities had been fully explored.

Whatever were the conditions for next year's competition the rules ought to be laid down at once so that the designers and constructors could begin without the delays that were always inherent from having the rules given out late.

The ultimate aim of the competitions ought also to be carefully considered. Were training or high speed machines wanted? This point should be carefully considered and the rules drawn up accordingly.

Everyone knew that the machines were expensive to build. The only object in doubt was the performance. It is a point for consideration whether another object to be met is the production of the cheap aeroplane. In order to attain this

end it may perhaps be desirable in any future competitions for the Air Ministry to link up with the offer of a prize the condition that they should have the right to purchase 25 or 50 of whatever aeroplane won the prize at a specified price.

The result would be that the designers would have to use the cheapest engines and keep down the costs of construction because they would know that they might have a number of machines to build at that price.

He wished to stress the importance of not deciding too hastily to leave the possibilities of the present machines unexplored.

Mr. A. H. R. FEDDEN congratulated Major Buchanan on his excellent analysis of the figures available. He was particularly interested in his remarks on the geared engine's failure to keep in the air, but he thought the whole blame ought not to rest with the engine. There was no difficulty about making a geared engine of this size satisfactory, provided that the aeroplane designer understood the problem of torque foot-lbs on an engine of this type. He was never asked what were the torque foot-lbs. of the geared "Cherub" engine or some of the mountings that were put forward would not have materialised in their present form.

Major Buchanan showed some doubt as to the h.p. necessary for single and two-seaters and suggested 40 h.p. for the latter. Was that 40 h.p. wanted all the time or was it wanted for short periods and then less h.p. for general flying, because he thought that that would considerably affect the ultimate size of the light aeroplane engine. He rather gathered that about 25-30 h.p. was wanted for general flying and 40 h.p. only for special circumstances; perhaps ten minutes every two or three hours. If that was so, in his opinion, after examining three of the Bristol "Cherubs" that had been used in the competition it was quite certain that with another year's development the 1,100 c.c. engines could be made to run for 100-150 hours. According to his calculations the "Wee Bee" and Bristol machines had a petrol consumption of 33½ m.p.g. with an average speed of 35 m.p.h. In the 1923 competitions the 87 m.p.g. was achieved with special tuning and irrespective of performance. From the rough figures he had been able to get out the 1,100 c.c. engine would do over 42 m.p.g. at 44 m.p.h., which compared well with the 1923 performances.

As regards engine size, he quite agreed with Mr. Sayers about power, and thought that probably an engine of larger capacity with the same power could be maintained at a slightly less cost of upkeep, but not very much.

Mr. F. SIGRIST said as regards low weight and also low h.p. to produce anything efficient was very expensive and he was therefore persuaded that it would be cheaper to build a slightly larger machine. In the same way a larger engine could be produced more cheaply provided that the same efficiency was not aimed at. Efficient engines meant using high grade materials and a high degree of accuracy. The Ford engine was probably quite remarkably inefficient, but it was cheap to produce.

In his opinion the importance of the cost of petrol consumption in comparison with other costs was negligible.

Flight-Lieutenant SODEN asked when a light aeroplane ceased to become a light aeroplane.

What was wanted was a machine which one could use when going away for week ends, and of sufficient engine power to get one home through the worst of weather.

He had an Austin Whippet which could carry everything he wanted in the way of week-end kit, but there was no place to put a suit case. The machine could be easily folded and put into any garage. His petrol consumption was

about 25 miles per gallon. He believed the 50 h.p. engine of low revs. was what would eventually be found most suitable.

His engine of this horse-power could be easily removed by two men.

The CHAIRMAN, before calling upon Major Buchanan to reply, said that he was in sympathy with some of the speakers. He thought we were in danger of confusing two things in these light aeroplane competitions. The competitions originated from successful trials of gliders, but a glider could not be used to fly from place to place. He thought that it was unfortunate that the glider competitions had influenced the choice of a site for the competitions of light aeroplanes. He had a personal objection to Lympne as a site, as it was too far away to get to easily, but a more serious objection was to be found in the presence of a ridge of hills mentioned by Major Buchanan, the up-currents along which assisted the light aeroplane to overcome the forces of gravity. The presence of this ridge, which is alleged to be the reason why the site was chosen, made accurate figures of performance difficult, if not impossible, to obtain. Accurate performances could only be recorded from trials at some place where atmospheric conditions were more normal. One could not really rely on the accuracy of any deduction about aerodynamical efficiency or fuel consumption from the trials at Lympne. When a machine was recorded to fly 87 miles on a gallon of petrol, he wondered what the figure would have been if there had been no up-currents.

He thought that sport and business were being perhaps rather confused in the development of the light aeroplane. Lightness in itself was not of paramount importance, but only in so far as it corresponded with cheapness. No doubt it was very difficult to get any reasonable idea of the costs of manufacture and upkeep by trials on a small scale, but he would have liked to have heard more about this side of the question. Whether one wanted to use light aeroplanes for private purposes or as training machines, or for special purposes in the Dominions, the cost of manufacture and upkeep should be the governing consideration.

He could not resist congratulating the Royal Aero Club on the accuracy of their methods of measurement, which enable them to record the number of hours flown by an aeroplane to four places of decimals, or about two-fifths of a second. Finally, he congratulated Major Buchanan on the skilful way in which he had analysed the data and put the results on record, and on the fact that his paper had produced such an interesting discussion.

In his reply to the discussion, Major BUCHANAN said that probably Major Mayo had not had time to read his remarks at the beginning of the paper. "I wish to say that the views expressed in this paper are my own personal views and do not in any way represent the official views of the Air Ministry, nor indicate the policy to be pursued." It was too late for him to start that evening on a discussion of the relative efficiency of large and small aircraft. He had endeavoured in his paper to give the figures exactly as they had been ascertained. He would hesitate to agree that large aeroplanes could be made with the same aerodynamical efficiency as the small types under discussion. With regard to the slow speed records, in every case the results were higher than the stalling speed estimated by the designer.

Petrol consumption might not be the prime consideration, but it was an important consideration that affected the size and cost. He did not think a 1,100 c.c. engine necessary for single-seaters, because in the R.A.F. it was found that the D.H.53 with a 750 c.c. Blackburn engine was quite satisfactory. The performance was quite good and there was no difficulty in handling and the structure was not unduly delicate. He thought the figures for the D.H.53 showed the position now arrived at as to the structure weight and standard of robustness

necessary to make a machine satisfactory and he treated the D.H.53 therefore as a standard on which comparisons might be made.

Mr. Manning had said structure weights could be interpreted in many ways. In the paper he had used the term as it was used in the calculations ordinarily carried out at the Air Ministry, which most people understood. He had arranged the figures on that basis so that it should be possible to make comparisons between the various types.

He thought everyone was agreed that the present performance was adequate except for the rate of climb off the ground. He agreed with Mr. Manning that engine reliability was related to aerodynamical efficiency, but the effect of the latter was only of a minor nature.

In reply to Sir Sefton Brancker, it was certainly possible and reasonable to test out aerodynamical ideas on these small machines before engaging on the expense of the larger ones. One could not produce the same useful load per horse-power in large aeroplanes as in small partly because of the factor of range. Large machines were expected to go much greater distances. The small aeroplane was for local rather than international use. Here petrol consumption also came in. If the consumption were kept down, the size of the engine and the first cost were kept down also.

As regards the question of limiting engine speed, he did not feel competent to deal with that from the engine designer's point of view.

Whilst some of the machines certainly were too light for economical construction, he did not consider that the D.H.53, for example, was. He was generally in agreement with Captain Sayers as to engine power. It certainly was important to keep down the horse-power of these aeroplanes to a minimum from the aerodynamical point of view. When he said that 40 h.p. was required he did not mean to fix an engine of 1,100 c.c., 1,500 or 2,000 c.c., he merely said that 40 h.p. was required with an engine speed which would give reliability and a propeller speed to give a reasonable propeller efficiency. He would like to get away from the motor car practice of thinking in terms of cubic centimetres. The aircraft designer was concerned only with power, weight and speed.

He agreed with Flight-Lieutenant Haig that with low-winged monoplanes there was a danger when making a forced landing. He did not agree with Flight-Lieutenant Soden that the h.p. ought to be increased unless experience proved it was absolutely necessary, so far experience showed that a slight increase should suffice. He thought it was unfortunate at Lympne that the two-seaters were flying with engines running at maximum revolution to produce 35 h.p. In flying at that power it was established that the climb off the ground was hardly sufficient, but owing to the high propeller speed the propeller efficiency at slow speed could not be high. Forty horse-power was wanted, but the engine power ought not to be pushed up beyond that.

In reply to Mr. Fedden, obviously geared engines had great advantages over ungeared engines if they could be made satisfactorily and he was glad to hear this might be done.

Mr. Fedden asked about reasonable power for single-seaters and two-seaters. The D.H.53 with 750 c.c. was flying very well and he thought 25 h.p. was ample for ordinary straight flight in two-seaters, but more engine power was required for taking off and to give a reasonable rate of climb.

He was glad to have Mr. Feddon's correction of his figures of consumption, but the difference between 30 and 33½ m.p.g. did not materially affect the comparison.

He thought Mr. Sigrist must have built his machine regardless of cost to get it so light, and he did not think expensive construction was necessary.

He agreed with the Chairman that the accuracy of the figures was not very high and he regretted that he had no better figures to put forward, but he hoped that they would have really reliable results from Martlesham when all the machines had been tested there, as he hoped would be the case.

It should not be forgotten that the art of designing aircraft of this type was in its infancy. The experience available was small even when compared with other types of aircraft and very small indeed compared with any other mechanical vehicle. For this reason it was reasonable to expect considerable improvements even in a short time. It was easy and perhaps prudent commercially to accept the fact of our limited experience and increase the power and size to bring the aircraft within the limits of such experience. From the point of view of both research and development, however, such a step could not be considered real progress.

ROYAL AERONAUTICAL SOCIETY

(Founded 1866).

Patrons: H.R.H. the Prince of Wales, K.G., Group Captain H.R.H. the Duke of York, K.G., R.A.F.
President: Lord Weir of Eastwood.
Vice-President: Major-General Sir R. M. Ruck, K.B.E., C.B., C.M.G.
Chairman: Lieutenant-Colonel H. T. Tizard, A.F.C., F.R.Ae.S.
Vice-Chairman: Lieutenant-Colonel A. Ogilvie, C.B.E., F.R.Ae.S.

Council

Prof. L. Bairstow, C.B.E., F.R.S., F.R.Ae.S.
Maj.-Gen. Sir W. S. Brancker, K.C.B., A.F.C.
Griffith Brewer, Esq., F.R.Ae.S.
Wing Commander T. R. Cave-Browne-Cave, C.B.E., F.R.Ae.S.
Sir Mackenzie D. Chalmers, K.C.B., C.S.I.
C. R. Fairey, Esq., C.B.E., F.R.Ae.S.
Prof. C. Frewen Jenkin, C.B.E., F.R.Ae.S.
Major A. R. Low, A.M.I.E.E., F.R.Ae.S.
W. O. Manning, Esq., A.F.R.Ae.S.
Lieut.-Col. J. T. C. Moore-Brabazon, M.C., M.P., F.R.Ae.S.
J. D. North, Esq., F.R.Ae.S.
Lieut.-Col. Mervyn O'Gorman, C.B., D.Sc., F.R.Ae.S.
J. L. Pritchard, Esq., F.R.Ae.S.
Colonel the Master of Sempill, A.F.C., A.F.R.Ae.S.
Sir Napier Shaw, F.R.S., D.Sc., F.R.Ae.S.
Major R. V. Southwell, A.F.R.Ae.S.
Major H. E. Wimperis, O.B.E., F.R.Ae.S.
R. McKinnon Wood, Esq., A.M.Inst.C.E., F.R.Ae.S.

Honorary Treasurer: Mr. A. E. Turner.
Honorary Librarian: Mr. J. E. Hodgson.
Secretary: Lieutenant-Colonel W. Lockwood Marsh (late R.A.F.), A.F.R.Ae.S.
Offices: 7, Albemarle Street, London, W.1.

Aims

The Society exists for the furtherance of the Science of Aeronautics, and its activities fall into the following headings:—(1) Protecting the interests of the aeronautical profession by conferring a technical status on those qualified for such distinction. It acts as the professional society or institution of qualified aeronautical engineers. (2) Organising discussions and publishing papers on subjects of importance in connection with the various branches of aeronautical science. (3) Encouraging and assisting technical students who desire to adopt the aeronautical profession for their careers. (4) Providing an organisation wherein those interested in aeronautics from scientific or other motives, but who are not professionally connected with aviation, may meet together, have opportunities of study and keep themselves in touch with aeronautical affairs.

Membership

The membership is divided into two categories:—

(*a*) *Technical*—(1) *Students*: Reserved for those under the age of 26 who are receiving a technical training such as will fit them in due course to become Associate Fellows. No entrance fee; *Subscription*, 1 guinea.

(2) *Associate Fellows*: Reserved for those who are duly qualified in accordance with the Regulations. Entitled to use the letters A.F.R.Ae.S. after their names. *Entrance fee*, 3 guineas; *Subscription*, 4 guineas.

(3) *Fellows*: Reserved for those who have attained to considerable eminence in the science of aeronautics, and are duly qualified in accordance with the Regulations. Entitled to use the letters F.R.Ae.S. after their names. *Entrance fee*, 5 guineas; *Subscription*, 6 guineas.

(*b*) *Non-technical* (open to all).—*Members*: All who desire to support the Society are eligible. *Entrance fee*, 1 guinea; *Subscription*, 4 guineas.
Foreign Members: Ditto. Domiciled abroad. No entrance fee; *Subscription*, 2 guineas.
Associate Members: Ditto. No entrance fee; *Subscription*, 2 guineas.

Privileges

Members in any of the above grades are entitled to attend the Society's lectures, receive the monthly Journal free of charge and consult books in the Society's library. All grades except Associate Members are entitled to borrow books from the library. Students and Associate Members are not entitled to vote.

Publications

THE JOURNAL OF THE ROYAL AERONAUTICAL SOCIETY, which is published monthly, contains notices of the Society's activities, full reports of all lectures (and discussions thereon), original scientific papers, reviews of aeronautical books, etc. A classified list of all articles published in the last six years may be obtained on application to the Secretary.

Original papers of a fundamental character in the science and technology of aeronautics are published from time to time as "Transactions of the Royal Aeronautical Society."

A complete list of the Society's other publications may be obtained on application to the Secretary.

Library

The library, which is housed at the Society's Offices, 7, Albemarle Street, W.1, contains a valuable collection of exceedingly rare historical books as well as constituting a good reference library of modern aeronautical literature. It is open for the use of all members from 9.30 a.m. to 5 p.m. on weekdays (9.30 a.m. to 12 noon on Saturday), and on the table are to be found the leading aeronautical and engineering papers of every country in the world.

Lectures

During the winter months meetings are held fortnightly, at which papers are read, followed by discussions, on a wide range of subjects covering the whole field of aircraft design and operations. They are held at 5.30 p.m. Members are admitted without tickets, and may obtain tickets for their friends on application to the Secretary.

Educational Lectures are also arranged in various centres throughout the country from time to time.

APPLICATION FOR MEMBERSHIP

I.....*desire to become a*

Fellow.
Associate Fellow
Student
Member
Foreign Member
Associate Member

(Strike out words not required.)

Kindly forward me an application form.

Signature.....

Address.....

.....

.....

To THE SECRETARY,
Royal Aeronautical Society,
7, Albemarle Street,
London, W.1.